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(CONTINUATION OF THE OHIO NATURALIST)

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and of the

OHIO STATE UNIVERSITY SCIENTIFIC SOCIETY

VOLUME XXI — 1920-21

OHIO STATE UNIVERSITY

COLUMBUS

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The Ohio Journal of Science

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REPORT OF THE THIRTIETH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE.

Columbus, May 14th and 15th, 1920.

The Thirtieth Annual Meeting of the Ohio Academy of Science was held at Ohio State University, Columbus, Ohio, May 14 and 15, 1920, under the presidency of Professor Frederick C. Blake. Sixty-nine members were registered as in attendance; thirty new members were elected.

General Program.

Friday, May 14.

11:00 a. m.—Business Meeting.
12:30 p. m.—Luncheon.
2:00 p. m.—Reading of Papers in General Session.
3:30 p. m.—Lecture by Professor Dayton C. Miller, Case School of Applied Science, Cleveland, on "Photographing Sound Waves from Large Guns and Projectiles."
4:30 p. m.—Reading of Papers in Sectional Meetings.
6:00 p. m.—Dinner.
7:30 p. m.—Address by the President of the Academy, Professor F. C. Blake, Ohio State University, Columbus, on "The Einstein Theory of Relativity and Gravitation."
8:30 p. m.—Demonstrations and Social Gathering.

Saturday, May 15.

9:00 a. m.—Adjourned Business Meeting.
10:00 a. m.—Reading of Papers in Sectional Meetings.

Minutes of Business Meetings.

The first business session was called to order by President Blake, at 11:00 A. M., on Friday, May 14. An adjourned session was held at 9:00 A. M. on the following day.

The appointment of the following committees for the meeting was announced by the chair:

Committee on Membership—C. L. Metcalf, J. W. Bridges, C. W. Reeder.

Committee on Resolutions—F. H. Herrick, E. L. Fullmer, W. G. Hormell.

The following Auditing Committee was elected by the Academy: J. W. Bridges, R. J. Seymour.

The following Nominating Committee was elected by the ballot of the Academy: R. C. Osburn, T. M. Hills, F. C. Blake.

Report of the Secretary.

The following report by the Secretary was received and ordered filed.

May 14, 1920.

To the Ohio Academy of Science:

Much of the work of the Secretary has been in connection with the Executive Committee and other committees, and is covered by the committee reports; much of the balance has been mere routine.

The circular of information was reprinted, as directed by the last annual meeting, and distributed with the preliminary announcement of this meeting.

A brief report of the Twenty-Ninth Annual Meeting was prepared for *Science*, and appeared in the number for August 1.

Arrangements were made with the Publication Committee for the appearance of the full report in the first issue of the Ohio Journal of Science for the current year; and it is hoped that this may become the established custom.

The usual notices of the present meeting were sent to the Columbus dailies.

In conference with the President, the Secretary arranged with Dr. S. J. Barnett, of the Carnegie Institution of Washington, to represent the Ohio Academy at a convention of the National Public Works Department Association, held in Washington, D. C., on January 13th and 14th. In reporting his attendance at the convention, Dr. Barnett writes as follows: "I certainly approve most strongly of the work of the Association, and I believe the movement worthy of any help the Academy can give it by passing a resolution in its favor, by interviewing Ohio Representatives and Senators, and by financial assistance if that should be practicable. I hope the movement is successful, and I am

glad to have had an opportunity to do a very little for it." The Secretary has the full minutes of this convention on file and available for any members interested. They contain the following statement: "The Finance Committee notified the Convention that the need of money was acute" and "recommended that each participating society be asked to assess their members at least one dollar per man." Nothing further has been heard concerning this matter.

Two requests for data concerning the membership and research funds of the Academy have been received from the National Research Council, and the desired information has been supplied.

On April 23d and 24th the Secretary represented the Ohio Academy of Science at the very interesting Semi-Centennial of the Wisconsin Academy of Sciences, Arts, and Letters in Madison. This was done at the request of the President, and was made financially possible, without expense to the Academy or to the Secretary, through the generosity of a group of Columbus members, to whom the Secretary wishes to express his very genuine thanks, although he does not know their names.

Respectfully submitted,

EDWARD L. RICE, *Secretary*.

Report of the Treasurer for the Year 1919-20.

The report of the Treasurer was received as follows, and referred to the Auditing Committee, whose report is appended.

May 15, 1920.

The Treasurer's report contains only such statements as presented before May 15th. There are a number of bills outstanding that will have to be taken care of in the next annual Treasurer's report. This accounts for the apparent decrease in the amount of the Treasurer's expenses for the current year but will be increased by the bills included in next year's account.

Independent Print Shop, Delaware, Ohio	$ 45.25
Spahr & Glenn, Printers, Columbus, Ohio	2.50
E. L. Rice, Secretarial expenses	8.14
A. E. Waller, Treasurer's expenses	5.20
T. C. Mendenhall, Coupons cashed from Liberty Bond	4.15
150 paid subscriptions to Journal	150.00
Liabilities	$215.24
Assets, balance in bank, May 13, 1920	$363.90
Received from C. W. Reeder from sale of publications	16.90
Total assets	$380.80
Less	215.24
	$165.56

Respectfully submitted,

A. E. WALLER, *Treasurer*.

The above accounts have been audited and found correct.

J. W. Bridges,
R. J. Seymour,
Auditing Committee.

Report of the Executive Committee.

The report of the Executive Committee was received as follows and ordered filed.

May 14, 1920.

To the Ohio Academy of Science:

Two meetings of the Executive Committee have been held during the year. At the first, January 21st, all members were in attendance; at the second, held this morning, the following were present: F. C. Blake, A. E. Waller, Wm. McPherson, E. L. Rice.

A considerable part of the work of the Committee has been carried on through correspondence.

The action of the President and Secretary, delegating Dr. Barnett to represent the Academy at the convention of the National Public Works Department Association on January 13th, was approved.

The year has been a phenomenal one in the matter of resignations on the part of officers; and the Committee has made the following appointments to fill vacancies:

A. E. Waller, Treasurer, vice W. J. Kostir.
C. D. Coons, Vice-President for Physics, vice M. E. Graber.
J. A. Culler, Vice-President for Physics, vice C. D. Coons.
T. M. Hills, Vice-President for Geology, vice J. E. Hyde.

Sixteen new members have been elected, subject to the ratification of the present meeting.

In selecting May 14th and 15th as the date of the present meeting, the Committee hoped to secure a date at once early enough to avoid the rush of the close of the school and college year and late enough to afford a reasonable prospect of good weather for possible field trips. Several complaints have been received. Does the Academy wish to fix the date for next year or to give any instructions to the incoming Executive Committee?

No invitations were received for the present meeting except the very welcome and very cordial standing invitation from Columbus. Tentative invitations from Alliance and Cleveland were postponed to a later date.

Perhaps the most important action of the Committee was the completion of the affiliation with the American Association for the Advancement of Science, authorized by the Academy at its last meeting and referred to the Committee with power to act. By the terms of this affiliation the Academy surrenders nothing of its present autonomy, but becomes entitled to representation in the Council of the American

Association. It is hoped that the affiliation may lead to an increase in the membership of both societies and to a mutually beneficial co-operation. The essentials of the plan are as follows:

1. All arrangements for the affiliation must be completed within the first six months of 1920.

2. The Treasurer of the Ohio Academy is authorized to collect the joint dues from members of the two organizations and to transmit the proper share to the Treasurer of the A. A. A. S.

3. By action of the last Annual Meeting, the annual dues of the Ohio Academy of Science are now two dollars; those of the A. A. A. S. are five dollars. The joint dues for members of both societies are six dollars, of which four dollars go to the A. A. A. S. and two dollars to the Ohio Academy.

4. Members of the Ohio Academy who are not members of the A. A. A. S. may become such without the payment of the usual initiation fee of five dollars.

5. Members of the Academy who do not become members of the A. A. A. S. continue to pay only the dues of the Ohio Academy.

6. All members of the Ohio Academy who have already paid the five dollar 1920 dues in the A. A. A. S. may obtain a rebate of one dollar from the Treasurer of the Ohio Academy upon application accompanied by proper receipt.

No further steps have been taken in connection with the proposed affiliation with the Ohio Association of Technical Societies.

Respectfully submitted,

EDWARD L. RICE, *Secretary,*
For the Committee.

Report of the Publication Committee.

The following report of the Publication Committee was received and ordered filed. The recommendations embodied in the report were approved by the Academy.

The only publication issued during the year was the Annual Report of the Twenty-ninth Meeting (Proc. Ohio Acad. Sci., Vol. VII, Part 4, pp. 87-116.) The Secretary's report was printed in the November number of the OHIO JOURNAL OF SCIENCE. It is recommended that this become the regular procedure which will insure publication the same year as the annual meeting and make it possible for the members to have the report before the annual dues for the following year are collected. The committee believes that the Academy should continue the publication of special reports from time to time, as in the past. In this way the standing of the Academy outside of the state would be advanced.

Respectfully submitted,

JOHN H. SCHAFFNER, *Chairman.*

Report of the Trustees of the Research Fund.

The following report of the Trustees of the Research Fund was received and ordered filed. The financial portion of the report was referred to the Auditing Committee, whose report is appended.

To the Ohio Academy of Science:

The Trustees of the Research Fund submit the following report for the year ending May 1, 1920:

During the year payments have been made to the following persons for the purposes indicated:

F. C. Blake: For the purchase of a specially sensitive galvanometer for use in an investigation already under way, and for materials purchased under previous grants for which bills had not been rendered. The entire cost of the galvanometer was paid from the Research Fund and it thus becomes the property of the Academy. It will be available for future use by any other member of the Academy who may need such an instrument in any investigation which has received the approval of the Trustees of the Research Fund. It is the desire and policy of the Trustees to give preference, as far as is possible, to grants of this kind where the expenditure of the money not only aids the investigator but also results in a valuable addition to the material resources of the Academy.

Paul B. Sears: To aid in the study of Ohio vegetation.

W. H. Bucher: To aid in the making of a geological map of the disturbed area in Adams County, Ohio.

L. B. Walton: For a continuation of his study of fresh water organisms.

Miss Elsie Jordan: For work in relabeling the Harper collection of Naiades (under the direction of W. H. Bucher).

In grants already made there are unexpended balances, due on the rendering of a satisfactory statement, to

A. E. Waller: For aid in a study of Ohio vegetation; to

L. B. Walton and W. H. Bucher: For the objects indicated above; and to

L. C. Hopkins: To aid in making a collection of Pteridophytes, and in the determination of the water-shed of Ohio. In these last two the expenditure is to be mostly for the printing and distribution of circular letters.

Below is a statement of receipts, expenditures, and liabilities, according to which there is an available balance of about four hundred dollars from which grants will be made upon application approved by the Trustees.

Vouchers for all expenditures are submitted herewith.

RECEIPTS.

Cash in bank, May 30, 1919	$678.57	
Interest on Liberty Bond, June 2, 1919	7.45	
Check from Mr. McMillin, April 12, 1920	250.00	
Interest on Liberty Bond, April 21, 1920	31.87	
		$967.89

EXPENDITURES.

F. C. Blake, June 12, 1919	$ 31.92	
F. C. Blake, Oct. 10, 1919	150.00	
Paul B. Sears, Nov. 3, 1919	22.44	
W. H. Bucher, Nov. 12, 1919	89.06	
L. B. Walton, Dec. 16, 1919	17.29	
Elsie Jordan, Dec. 16, 1919	12.50	
		323.21

Cash balance in bank, May 1, 1920	$644.68
Total assets, (Liberty Bond at par)	$1,144.68

LIABILITIES (under grants).

A. E. Waller	$75.00	
W. H. Bucher	98.44	
L. C. Hopkins	50.00	
L. B. Walton	20.31	
		243.75

Excess of available assets above liabilities	$400.93

(Signed), T. C. MENDENHALL,
HERBERT OSBORN.

The financial statement in the above report has been audited and found correct.

J. W. BRIDGES,
R. J. SEYMOUR,
Auditing Committee.

Report of the Library Committee.

For the Library Committee, Mr. Reeder, of the Ohio State University Library, presented the following report, which was received and ordered filed.

May 14, 1920.

To the Ohio Academy of Science:

The Library Committee begs leave to submit the following report:

(1) The sale of publications during the year has been above normal, the total amount received being $27.75. On July 15, 1919, $10.85 of this amount was turned over to Mr. Kostir, and the balance $16.90 is now ready for the Treasurer.

(2) The Proceedings of the 29th Annual Meeting appeared in the OHIO JOURNAL OF SCIENCE for November, 1919, and a few months

later the reprints were received and mailed to persons whose names appear in that report on the membership roll. The report was also sent to the sixty-five institutions on the exchange list.

(3) The receipt of exchanges by the Academy has been about as usual with a slight increase in the foreign group due to a resumption of near-normal transportation conditions and the clearing out of accumulations by the International Exchange Service of the Smithsonian Institution.

(4) During the year a thousand cards were added to the Union Catalog of Scientific Periodicals by the Oberlin College Library. It is known that other libraries have contributions of cards ready whenever there is need of them, but the matter has not been pushed on account of the difficulty experienced in the large libraries in keeping even with current work on account of depleted staffs.

(5) During the past year the University Library made loans of 42 books to nine Ohio Colleges. It is not known whether or not the professors desiring these books are members of the Ohio Academy, but it is hoped they are. The library offers to lend to any scientist in the Academy, through his institutional library, any publication not needed for immediate use. This service ought to be developed more extensively and the Library stands ready to discharge its obligation to the men and women of the Ohio Academy who are engaged in research and need more book facilities than are available in their libraries.

Respectfully submitted,

C. W. Reeder.

Report of the Committee on Legislation.

The following report of the Committee on Legislation was received and ordered filed. The Committee was continued.

Your Committee on Legislation is unable to report any very substantial progress in the matter of securing state support but would recommend that the committee be continued or another committee appointed to continue the effort. Owing to the session of last winter being an adjourned session and averse to taking up new measures and also the varied questions of intense debate that developed during the session and the attitude of members toward the introduction of any new measures involving new appropriations, the time seemed inopportune. Moreover, there are one or two points which it seems desirable to clear up before offering a specific form of bill.

For the information of the members we submit the following draft of a bill which embodies the points it seems desirable to include.

It may be noted that there is some question as to the form in which an act may best be stated which provides that the service of the Academy may be mandatory while the obligation of the state can only operate during the life of an appropriation which under the constitution is limited to the biennial period. The committee has attempted to include in one bill the provision that the Academy may function as an advisory body for the state and also that the state shall support the Academy in the matter of publication and expenses.

Suggestions from members as to the best manner in which this can be accomplished will be welcomed by the committee if continued.

A BILL

To provide for the publication of the Proceedings of the Ohio Academy of Science and Support and Service of the Academy.

Be it Enacted by the Eighty-third General Assembly of the State of Ohio:

SECTION 1. That there is hereby appropriated the sum of $2,000 per annum during the biennium for the Ohio Academy of Science for the support of its publications and for the payment of expenses of the society which may include the salary of a secretary.

SEC. 2. The Proceedings of the Academy, aside from its regular distribution to members and exchanges, shall be distributed one copy to each public library and to each university, college and first grade high school in the state. The exchanges received shall be kept available to the citizens of the state through the library of the State University or such other channel as may be determined.

SEC. 3. The services of the Academy shall be available to the state or any of its officers in any matter in which the consideration of scientific facts, policies or problems is involved, and the officers of the state may call upon the Academy through its properly elected officers or committees appointed by its officers for such consultation and advice as may be of service to them in their duties, the members of such committees to receive no compensation for this service further than necessary expenses of travel or other outlay in the performance of their duty and no member of the Academy while serving as a member on such committee shall be eligible for expert service involving compensation from the state. The President of the Academy shall serve as the medium of communication with the Academy.

Respectfully submitted,

HERBERT OSBORN,
T. C. MENDENHALL,
EDWARD L. RICE.

Report of the Committee on War Roll.

The following report of the Committee on War Roll was received and ordered filed. The Committee was discharged.

To the Ohio Academy of Science:

The committee appointed a year ago to continue the collection of data concerning the war record of Academy members has held no meeting during the year; but a call for the desired information was included this year, as last, in the preliminary notice of the Annual Meeting. Forty members responded to this call. The data collected are in the possession of the Secretary, and will be transferred for permanent record to the cards of the Secretary's membership catalog.

Respectfully submitted,

EDWARD L. RICE, *Secretary,*
For the Committee.

Report of the Committee on Election of Fellows.

The following report of the Committee on Election of Fellows was accepted and ordered filed.

May 14, 1920.

To the Ohio Academy of Science:

The Constitution, as amended in 1919, delegates the election of fellows to a joint committee consisting of the Vice-Presidents and the Executive Committee. Nine of the eleven votes are necessary to an election.

Much of the work of the joint committee has been done by correspondence; but a meeting held this morning gave opportunity for free discussion. Seven members of the committee were present at this meeting; the other four were represented by more or less fully instructed proxies. The entire mode of procedure has been as follows:

As only fellows are to be eligible to office and to membership in the Executive Committee, it was agreed that all past and present Officers and Executive Committee members should become fellows. These number fifty-six.

Membership lists were then mailed to all members of the Committee, to be checked as ballots and returned to the Secretary for tabulation. Ten of the eleven members of the Committee voted. No member of the Academy received the necessary nine ballots, although two lacked but one vote each. The names of members receiving any votes were then mailed to the Committee members to serve as a list of nominations for consideration at this morning's meeting.

From this list fifty-eight fellows were elected, making the total number one hundred and fourteen. The fellows will be designated by some distinguishing mark in the next list of members published.

Your committee believe that their work has been conservative. They have endeavored to guard against the election of any undesirable fellows; desirable candidates have undoubtedly been omitted. Such errors can be easily rectified by succeeding committees.

Respectfully submitted,

EDWARD L. RICE, *Secretary,*
For the Committee.

Election of Officers.

The following officers and committee members for 1920-21 were elected by the ballot of the Academy:

President—MR. W. H. ALEXANDER, U. S. Weather Bureau, Columbus.

Vice-Presidents:

Zoology—Professor F. H. KRECKER, Ohio State University, Columbus.

Botany—Professor C. H. OTIS, Western Reserve University, Cleveland.

Geology—Professor W. H. BUCHER, University of Cincinnati, Cincinnati.

Physics—Professor D. C. Miller, Case School of Applied Science, Cleveland.

Medical Sciences—Professor Ernest Scott, Ohio State University, Columbus.

Psychology—Professor H. A. Aikins, Western Reserve University, Cleveland.

(On the resignation of Professor Aikins, the Executive Committee appointed Professor J. W. Bridges, Ohio State University, Columbus, to fill the vacancy.)

Secretary—Professor E. L. Rice, Ohio Wesleyan University, Delaware.

Treasurer—Dr. A. E. Waller, Ohio State University, Columbus.

Elective Members of Executive Committee—Professor F. C. Blake, Ohio State University, Columbus; Professor C. G. Shatzer, Wittenberg College, Springfield.

Member of Publication Committee—Professor L. B. Walton, Kenyon College, Gambier.

Trustee of Research Fund—Professor Herbert Osborn, Ohio State University, Columbus.

Member of Library Committee—Professor F. O. Grover, Oberlin College, Oberlin.

Representatives on Editorial Board of Ohio Journal of Science:

Zoology—Professor R. A. Budington, Oberlin College, Oberlin.

Botany—Professor Bruce Fink, Miami University, Oxford.

Geology—Professor G. D. Hubbard, Oberlin College, Oberlin.

Physics—Professor S. J. M. Allen, University of Cincinnati, Cincinnati.

Medical Sciences—Professor F. C. Waite, Western Reserve University, Cleveland.

Psychology—Professor H. A. Aikins, Western Reserve University, Cleveland.

Election of Members.

The Membership Committee reported fourteen names for election to membership; sixteen additional names, previously approved by the Executive Committee and marked with (*) in the following list, were presented for ratification. All were elected, as follows:

*Anderson, Donald B., Botany; Botany and Zoology Bldg., Ohio State University, Columbus.

Arps, G. F., Psychology; Ohio State University, Columbus.

*Balduf, Walter V., Zoology; Dept. of Zoology and Entomology, Ohio State University, Columbus.

Berger, F. L., Physics; 121 E. Long St., Ada.

*Bohl, Ray Anderson, Anatomy, Zoology; 838 May St., Akron.

*Bowman, H. H. M., Botany, Zoology; University Science Hall, Cherry and Page Streets, Toledo.

*Braun, E. Lucy, Botany; 2702 May Street, Cincinnati.

*Brewer, P. H., Chemistry; McKinley High School, Canton.
Burtt, Harold E., Psychology; Department of Psychology, Ohio State University, Columbus.
Ditto, R. C., Physics; 316 W. Eighth Avenue, Columbus.
Evans, Wm. Lloyd, Chemistry; Dept. of Chemistry, Ohio State University, Columbus.
Guyton, F. E., Zoology, Entomology; Dept. of Zoology and Entomology, Ohio State University, Columbus.
*Harper, Arthur R., Botany, Zoology; 2479 Findlay Ave., Columbus.
Henderson, Wm. E., Chemistry; Dept. of Chemistry, Ohio State University, Columbus.
Householder, F. F., Physics; Municipal University of Akron, Akron.
Howard, C. C., Chemistry; Columbus.
Huber, Lawrence L., Zoology, Entomology; Dept. of Zoology and Entomology, Ohio State University, Columbus.
Kennedy, Clarence H., Entomology; Dept. of Zoology and Entomology, Ohio State University, Columbus.
*Kline, E. K., Chemistry, Public Health, Physics; Public Health Laboratories, Toledo.
*Kornhauser, Sidney Isaac, Zoology; Denison University, Granville.
*Kraatz, Walter C., Zoology, Entomology; Dept. of Zoology and Entomology, Ohio State University, Columbus.
*Kreider, Henry R., Chemistry, Public Health, Physics; University of Toledo, Toledo.
Miller, Dayton C., Physics; Case School of Applied Science, Cleveland.
Minchin, Howard D., Physics; Columbus.
*Pumphrey, Elva, Biology; Dept. of Biology, Ohio Wesleyan University, Delaware.
*Root, Eunice, Botany; Botany and Zoology Bldg., Ohio State University, Columbus.
*Schweikher, F. P., Nature Study, General Science, Agriculture, Botany, Zoology; 1623 Compton Road, Cleveland.
*Stover, Ernest L., Botany; Botany and Zoology Bldg., Ohio State University, Columbus.
*Tiffany, Lewis H., Botany; Dept. of Botany, Ohio State University, Columbus.
Todd, Frank E., Entomology, Zoology, Plant Pathology; Assistant State Entomologist, Yuma, Arizona.

Report of Committee on Necrology.

No deaths of members during the year were reported, and the report of the Committee on Necrology was happily omitted.

Report of Committee on Resolutions.

The following resolutions were presented by the Committee on Resolutions and adopted by the Academy.

1. The Academy desires to thank the Local Committee and the officers of Ohio State University for their efforts in making the Thirtieth Annual Meeting a success.

2. The Academy wishes to record an expression of its thanks to Mr. Emerson McMillin for his continued and generous support of scientific research in Ohio.

3. The Academy would also thank Professor Dayton C. Miller for an illustrated lecture upon his ingenious experiments in "Photographing Sound Waves from Large Guns and Projectiles."

4. The Academy further expresses its appreciation to the Secretary for his sustained and efficient services in forwarding its interests and thus contributing to the success of its meetings and work.

(Signed), F. H. Herrick,
E. L. Fullmer,
W. G. Hormell.

Conservation of Platinum and Potassium.

The following resolutions concerning the use and abuse of platinum and potassium were introduced by Professor J. R. Withrow and unanimously adopted by the Academy. Professor Withrow and the Secretary were appointed a special committee to secure the publicity of the resolutions and to urge the importance of the subject alike to scientists and the general public.

(1)

Whereas, The price of platinum has risen in the past twenty years from 50 cents or less per gram to as high as \$5.30 in the present year, or in the neighborhood of 1000% increase in cost, making it prohibitive for educational or scientific work; and

Whereas, Cheap platinum as it was twenty years ago, would greatly ease and encourage research work in Physics and Chemistry and would doubltess greatly cheapen sulphuric acid, required in making phosphate fertilizers and perhaps quickly give us the key to the utilization of atmospheric nitrogen for use in agriculture as a plant food; and

Whereas, The world's stock of platinum is small and the prospects for large additions to this stock are far from bright since the Russian deposits are understood to be approaching exhaustion and we have none as good in sight; and

Whereas, The chemical and electrical industries have absolute need for platinum, though they are continually seeking cheaper and as satisfactory substitutes; therefore,

Be it Resolved, That the Ohio Academy of Science commends the effort made in the dental profession and in the electrical industries to find substitutes for platinum in their work and urges all scientists to assist in every way with these important efforts at platinum conservation;

Be it Resolved, That the Ohio Academy of Science urges the dental profession and the electrical and other industries to reduce to a minimum the use of platinum in all places where its ultimate loss is certain;

Be it Resolved, That the Ohio Academy of Science condemns the use of platinum in jewelry and in any other way that is not productive of scientific or industrial advance or development;

Be it Resolved, That the Ohio Academy of Science urges the women of Ohio in the interests of science and the development of industry to abstain from the use of platinum as jewelry.

(2)

WHEREAS, The amount of potash salts is limited and their use in some connections is imperative; and

WHEREAS, Most chemical and other scientific texts and formularies have long been saturated with directions for the use of potash salts where sodium salts would serve as well; and

WHEREAS, There has on this account in the past existed an appalling waste in potash, of which the citation of the use of potassium cyanide in gold metallurgy for years where sodium cyanide would and does do as well may serve as an example; therefore,

Be it Resolved, That the Ohio Academy of Science urges all men of science to eliminate the use of potash where possible, and to publish the results of their experiments or report their experiences, favorable or unfavorable, to the Academy Secretary or to Professor Withrow at the Ohio State University.

Ohio Biological Survey.

An informal report was presented by Professor Herbert Osborn, Director of the Ohio Biological Survey, concerning the recent work of the Survey and its present financial limitations. The following resolution, presented by Professor E. L. Fullmer, was adopted by the Academy.

Resolved, That the Academy record its appreciation of the work of the Ohio Biological Survey and express its sincere hope that the work of the survey may be continued with increased support and activity in order that more rapid progress may be made in the investigation of pressing biological problems. The reports so far published have been of distinct service and furnish a solid basis for further progress while the organization in co-operation with the various universities and colleges gives opportunity for very effective association of the trained biological workers of the state. The authorities of the State University are assured of the continued interest and co-operation of the Academy in any measures which may advance this project.

Preservation of Wild Life of State.

At the suggestion of the Section for Zoology, Professor Herbert Osborn reported on the work of the State Department of Agriculture in providing preserves for the wild life of the State. The Academy expressed its hearty approval and appreciation of this work, and authorized the appointment of a committee to co-operate with the State authorities and to report to the next meeting a policy for the future work of the Academy toward the preservation of the native fauna and flora. The President appointed the Committee as follows: Herbert Osborn, Chairman; J. E. Carman, Bruce Fink, F. H. Herrick, M. M. Metcalf, C. G. Shatzer, E. N. Transeau.

Election of Patron.

On the recommendation of the Executive Committee, Mr. Emerson McMillin was unanimously elected a Patron of the Academy, in recognition of his many financial contributions to the research work of the Academy.

Representation in Council of A. A. A. S.

As an affiliated society, the Academy is entitled to a representative in the Council of the American Association for the Advancement of Science. The Secretary was appointed to serve in this capacity, with power to appoint a substitute in case of inability to attend a meeting of the Council.

Proposed Constitutional Amendment.

Notice was given of a proposed amendment to the constitution, to be submitted for action at the next annual meeting, providing for the nomination of candidates for fellowship in the Academy by two fellows, the election to remain as now provided.

Scientific Sessions.

The complete scientific program of the meeting follows:

Presidential Address.

"The Einstein Theory of Relativity and Gravitation," F. C. Blake

Public Lecture.

"Photographing Sound Waves from Large Guns and Projectiles" .... Dayton C. Miller

Symposium Before Physics Section.

The Constitution of the Atom:

(a) The Planetary Atom of the Physicist .... S. J. M. Allen
(b) Why Not One Kind of Atom Only? .... R. C. Gowdy
(c) Discussion, led by .... W. L. Evans

Papers.

1. Claws of Arachnids .... W. M. Barrows
2. The Arizona Boll Weevil (Anthonomus grandis var. thurberia) with Special Reference to Steps Taken by the Arizona Commission of Agriculture and Horticulture to Prevent its Establishment in Cultivated Cotton. Read by title .... Don C. Mote
3. Aphelopus theliae (Gahan) and the Changes Produced in Thelia by this Parasite. 15 min. (Lantern) .... S. I. Kornhauser
4. The Intestinal Parasites of Overseas Troops as Compared with Home Service Troops. 10 min .... S. I. Kornhauser
5. A New Disease, Black Tumor, of the Catfish. 5 min .... R. C. Osburn
6. Classification of the Opalinidæ. 10 min .... Maynard M. Metcalf
7. Geographical Distribution of the Opalinidæ. 15 min ... Maynard M. Metcalf
8. Factors in the Distribution of Aquatic Snails in Lake Erie. 20 min. (Lantern) .... F. H. Krecker
9. Caddis-fly Larvæ as Agents in Distribution of Fresh Water Sponges. 5 min. F. H. Krecker
10. Notes on Some Tropical Homoptera. 8 min .... Herbert Osborn
11. Generic and Specific Characters from the Male Genitalia of Syrphidæ (Diptera). 10 min. (Lantern) .... C. L. Metcalf
12. Some Myriapods of Put-in-Bay. 10 min. .... Stephen R. Williams
13. The Chondrocranium of Syngnathus fuscus. 20 min .... J. E. Kindred
14. Additions to the Birds of Ohio. 10 min .... Lynds Jones
15. Bird Migration Groups. 20 min .... Lynds Jones
16. Two Recently Destructive Clover Insects of Western Ohio. 5 min ..... T. H. Parks
17. The Preservation of Native Flora and Fauna. 10 min .... Herbert Osborn
18. New Economic Applications for the Mangrove. 8 min. (Lantern) H. H. M. Bowman
19. The Progress of Revegetation in the Katmai District. 15 min. (Lantern) Robert F. Griggs

20. Observations on the Edge of the Forest in the Katmai District. 15 min. (Lantern)..ROBERT F. GRIGGS
21. The Influence of Environment on Sexual Expression in the Hemp. 10 min. J. H. SCHAFFNER
22. A Double Mutant of the Hemp. 5 min......................J. H. SCHAFFNER
23. Translocation and Storage of Carbohydrates in Apple Fruit Spurs and Two-year-old Seedlings. 20 min..................SWARNA KUMER MITRA
24. Origin and Character of Schizogenous Resin Cavities in Avocado Fruits and Leaves. 15 min. (Opaque projection).........SWARNA KUMER MITRA
25. Origin and Character of Adventitious Roots in Cornus Pubescence. 15 min. (Opaque projection)............................SWARNA KUMER MITRA
26. Story of Citrus Fruits of Pinellas County, Florida. 5 min.............. KATHARINE DOORIS SHARP
27. Factors Controlling Transpiration.......................JASPER D. SAYRE
28. Certain Conditions that Hinder the Study of Botany in High Schools.. MAXIMILIAN BRAAM
29. Progress in Plant Microchemistry. 20 min.................H. C. SAMPSON
30. Sugar Syrup from Home Grown Sugar Beets. 10 min.....JAMES R. WITHROW
31. Some Farm Experiments in the Making of Syrup from Sugar Beets. 10 min. F. C. VILBRANDT
32. Some Pertinent Questions for Ohio Scientists. 30 min.
    (a) Sulphuric Acid and Kiln Plants and their Fumes.
    (b) The Errors of Ohio's Legal Kerosene Flash Point Apparatus—the Foster Cup.
    (c) The Unnecessary Use of Potassium Salts.
    (d) The Damage to Science and Industry by the Wastage of Platinum.
    JAMES R. WITHROW
33. Partial Solution of Certain Applied Chemical Problems. 30 min.
    (a) Saving of Platinum by the Use of Platinum Crucibles in Electro-analysis.
    (b) By a Modified Mercury Cathode Cell.
    (c) The Determination of Water in Substances Easily Decomposable Thermally.
    JAMES R. WITHROW
34. Gas Combustion Investigations. 10 min.
    (a) Quartz-apparatus.
    (b) Central Burner Type.
    (c) Devitrification of Quartz in Capillaries.
    F. C. VILBRANDT
35. The Thermionic Tube as a Useful Amplifying Tool of the Scientist. 20 min...A. D. COLE
36. A Seasonal Breakage of Watch Springs and Its Cause. 10 min........... SAMUEL R. WILLIAMS
37. Springs of Minimum Weight. 20 min.........................H. C. LORD
38. Relations between Atomic Numbers and the Wave Lengths of X-rays. 10 min..S. J. M. ALLEN
39. Relations between Absorption Coefficients and Wave Lengths of X-rays. 10 min..S. J. M. ALLEN
40. Characteristic Curves of Different Types of Thermionic Tubes. 15 min. A. D. COLE
41. Thermodynamics. 20 min................................LOUIS T. MORE
42. Electrification by Impact. 10 min......................HAROLD RICHARDS
43. On Self and Mutual Elastance and Capacitance. 15 min........F. C. BLAKE
44. Note on a Double Solenoid for the Production of Uniform Magnetic Fields. S. J. BARNETT

45. Observations on Eruptive Phenomena in the Valley of Ten Thousand Smokes. 15 min. (Lantern)........................... ROBERT F. GRIGGS
46. Diastrophism Still Continuing in the Great Lakes Region. 15 min....... E. L. MOSELEY
47. Clarion and Vanport Members in Ohio. 30 min.............. WILBER STOUT
48. A Pre-somite Human Embryo. 10 min. (Opaque projection)...C. L. TURNER
49. Relation of Catalase to Activity. 5 min...................... R. J. SEYMOUR
50. Some Features of Industrial Fatigue. 15 min.................. E. R. HAYHURST
51. Epidemic Encephalitis. 15 min. (Lantern).................. ERNEST SCOTT
52. Measurement of Blood Pressure by Resistance of Carbon Discs. F. P. DURRANT
53. Educative Characteristics of First Grade Children. 15 min...MARY E. MILLER
54. A Study of the Lowest Five Percent of College Students as Determined by the Army Alpha Examinations. 10 min................ HELEN MARSHALL
55. A Study of the Highest Five Percent of College Students as Determined by the Army Alpha Examinations. 10 min................ EARL R. GABLER
56. Experimentation in the Psychology of Music. 15 min...ESTHER L. GATEWOOD
57. Mental and Educational Tests of the Deaf. 10 min....... JEANNETTE REAMER
58. Syphilis and Delinquency. 15 min....................... FLORENCE MATEER

Demonstrations.

(a) Black Tumor of the Catfish................................ R. C. OSBURN
(b) Some Interesting Tropical Hemiptera..................... HERBERT OSBORN
(c) Caddis Cases Covered with Sponges...................... F. H. KRECKER
(d) Wax Models of 8 mm. and 12 mm. Chondrocrania of Syngnathus...... J. E. KINDRED
(e) Models of Pre-somite (Mateer) Human Embryo............ C. L. TURNER
(f) Specimens from the Valley of Ten Thousand Smokes..... ROBERT F. GRIGGS
(g) Wireless Telephone.. R. A. BROWN

THE PHYLOGENY OF THE ZYGOPTEROUS DRAGONFLIES AS BASED ON THE EVIDENCE OF THE PENES*

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This paper is merely the briefest outline of the writer's discoveries with regard to the inter-relationship of the major groups of the Zygoptera, a full account of which will appear in his thesis on the subject. Three papers[1] by the writer discussing the value of this organ in classification of the Odonata have already been published.

At the beginning, this study of the Zygoptera was viewed as an undertaking to define the various genera more exactly. The writer in no wise questioned the validity of the Selysian conception that placed the Zygopterous subfamilies in series with the richly veined "Calopterygines" as primitive and the Protoneurinæ as the latest and final reduction of venation.

However, following Munz[2] for the Agrioninæ the writer was able to pick out here and there series of genera where the development was undoubtedly from a thinly veined wing to one richly veined, *i. e.*, *Megalagrion* of Hawaii, the *Argia* series, *Leptagrion*, etc. These discoveries broke down the prejudice in the writer's mind for the irreversibility of evolution in the reduction of venation in the Odonata orders as a whole. Undoubtably in the Zygoptera many instances occur where a richly veined wing is merely the response to the necessity of greater wing area to support a larger body.

As the study progressed the writer found almost invariably that generalized or connecting forms were usually sparsely veined as compared to their relatives. The first startling discovery was that *Hypolestes* (*Ortholestes*) was a near relative of *Amphipteryx* and not Lestid at all, others followed; *Hemiphlibia* had no near relatives in the Cœnagrioninæ but was probably nearer the Megapodagrioninæ, that the minute *Micromerus* was the least specialized Libellagine genus that the Megapodagri-

*A second paper will appear in the Ohio Jour. of Sci. for December.

[1] Ent. News, July, 1916, Jan., 1917, July, 1917.

[2] Mem. Amer. Ent. Soc. No. 3, 1919.

onine penes were "Calopterygid" rather than Cœnagrionid. Building up from such discoveries the writer has been forced to the conclusions presented in this sketch.

The primitive Zygopter must have been a small insect no larger (if as large), than *Ortholestes*, *Miocora*, *Argiolestes*, or *Micromerus* that had a reduced venation, in which there were probably but two antenodals, in which M_3 and R_s arose near the subnodus, in which there may or may not have been a few more extra sectors than M_{1a}. That the breathing by caudal as well as by *abdominal gills* is a specialized method, the primitive Odonate method being by rectal gills.[3] That the development of the families and subfamilies was radiate and not serial.

These conclusions reverse some of our previous views. The nodus has passed distad in the richly veined Calopterygine series instead of having passed basad in the "reduced" Cœnagrionid wing. The forks of M_3 and R_s have changed very little, which agrees with venational studies in other orders. The wings have increased in size merely by the lengthening of some or all the veins and by the addition of extra sectors. Thus *the nodus is merely the apex of Sc*, which has been free to lengthen just as its sister longitudinal veins have lengthened and so has moved out as the wing increased in area, which has made the forks of R_s and M_3 appear to have moved basad more than they really have.

Interwoven with these are the two elusive factors:

1. Heredity, which tends to hang on to old structures; and
2. Orthogenesis, which may increase a tendency beyond the actual needs of the insect.

The writer hopes that his friends will deal leniently with these startling innovations until he is able to present the evidence in full. His own views have been completely reversed during this study.

The sixteen subfamilies of Zygoptera recognized by the writer fall into four major groups, or families, the *Agrionidæ*, *Lestidæ*, *Hemiphlebidæ*, and *Cœnagrionidæ*. The list of subfamilies will be discussed as a list because the writer has been unable to construct, without exceptions, a natural key based on either wings or penes. Probably the major groups can be defined in larval characters when these are better known. Drs. Calvert and Tillyard are in possession of material that should solve this problem.

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[3] See page 23.

I. **Agrionidæ.**
  1. *Megapodagrioninæ.*
  2. *Philoganginæ.*
  3. *Amphipteryginæ.*
  4. *Epallaginæ.*
  5. *Polythorinæ.*
  6. *Agrioninæ.*
  7. *Libellaginæ.*
  (8. *Platystictinæ?*)

II. **Hemiphlebidæ.**
  9. *Hemiphlebinæ.*

III. **Lestidæ.**
  10. *Perilestinæ.*
  11. *Synlestinæ.*
  12. *Lestinæ.*

IV. **Coenagrioninæ.**
  (8. *Platystictinæ?*)
  13. *Pseudostigmatinæ.*
  14. *Platycneminæ.*
  15. *Protoneurinæ.*
  16. *Cœnagrioninæ.*

I. Agrionidæ.

This family is roughly defined by a combination of characters: two rows or more of cells between M_{1a} and M_2 at the level of the stigma; no oblique vein between M_2 and R_s distad of the subnodus; naiadal labium cleft.

Known exceptions to the first character are *Trineuragrion* and *Tatocnemis* and the genera in the Platystictinæ. The inclusion of the latter here of course depends on the correctness of Fraser's identification[4] of the *Protosticta* naiad. When the study of the penes showed that *Hypolestes* (*Ortholestes*) was not Lestid but belonged near *Amphipteryx* the Selysian definition of Zygopterous families had to be discarded. That discovery put *Hypolestes* with its two antenodals into the Agrionidæ. With the bar against two antenodals in the Agrionidæ lifted, the Megapodagrioninæ became Agrionid on the strength of their extra sectors and the cleft labium in the naiad, (*Thaumatoneura*[5], *Argiolestes*[6]).

1. **Megapodagrioninæ.** Figs. 91–124. *Nesolestes*, (*Protolestes*)[7] (*Allolestes*), *Neurolestes*, *Podolestes*, *Trineuragrion*, (*Melanagrion*) *Riphidolestes*, *Argiolestes* (*Metagrion*) *Wahnesia*, *Podopteryx*, *Paraphlebia*, *Thaumatoneura*, *Rhinagrion*, (*Phenacolestes*), *Tatocnemis*, *Megapodagrion*, *Heteropodagrion*, *Dimeragrion*, *Allopodagrion*, (*Lithagrion*) *Philogenia*, *Heteragrion*, (*Mesagrion*), *Oxystigma*[8].

The most primitive genera in the above list are *Podolestes* and *Rhinagrion*. These in their simple venation, simple penes

[4] Rec. Ind. Mus. XVI, p. 465, 1919.
[5] Calvert, Ent. News 26, p. 300.
[6] Tillyard, Biology of Dragonflies, p. 278, "Mask—resembling that of the *Epallaginæ*."
[7] Parenthesis indicates that the penis has not been studied.
[8] Probably *Lestoidea* belongs in this subfamily. Its penis is unknown.

and appendages stand as generalized forms intermediate between the various specialized groups of this subfamily. The tips of branches are represented by *Podopteryx*, *Thaumatoneura Oxystigma* and *Tatocnemis*. The writer believes the primitive members of this subfamily to be very close to the ancestral Zygopter, in size, venation, penes and male appendages. This subfamily falls into three distinct groups by the penes and venation. 1. Afric-oriental, 2. Mexican; 3. South American.

2. **Philoganginæ.** Figs. 38–39. *Philoganga.*

A very archaic genus in which adjustment to great size was made by the hasty method of merely lengthening all the principal veins of the wing. While the naiad is not known the penis and venation indicate a position near the *Amphipterygínæ* and *Megapodagrioninæ.*

3. **Amphipteryginæ.** Figs. 82–90. *Hypolestes*, (*Pseudolestes*), *Diphlebia*, *Pentaphlebia*, *Amphipteryx*, *Devadatta.*

The simplest member of this series is the little *Hypolestes* in which there are but two antenodals. The penis of this genus, Figs. 88–99, is close to that of *Amphipteryx*, Figs. 86–87. It has none of the Lestine features found in Figs. 1–15. Needham described[9] what is probably its naiad but could not believe his eyes because of its "Calopterygine" characters that suggested *Diphlebia.*[10] These naiads with their unspecialized labia and antennæ are very close to those of the *Megapodagrioninæ.* The extremely discontinuous distribution of these small genera shows them to be very primitive.

4. **Epallaginæ.** Figs. 28–37 and 40–41. *Epallage*, *Anisopleura*, *Bayadera*, *Pseudophæa*, *Dysphæa.*

This series has its closest relatives in the *Polythorinæ* as is shown by the ventral abdominal gills in their naiads.[11] Both families are very primitive in the unspecialized antennæ and labia of the naiads but the pairs of gills are surely a specialization as none occur in the other Zygoptera nor in the Anisoptera. The male appendages in this subfamily are intermediate between the Megapodagrion type with dilated appendages and the Polythorine type with a basal spur. *Anisopleura* and *Epallage* are the more generalized genera.

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[9] Ent. News XXII. p. 151, 1911.

[10] Tillyard Proc. Linn. Soc., N. S. Wales, 34 pp. 370–383, 1909.

[11] Needham, Ent. News XXII, p. 149–150. 1911. (Anisopleura, Bayadera). Hagen, Zool. Anz. Vol. III, pp. 304–305, 1880. (Anisopleura, Bayadera). Ris. Tijdsch. v. Ent. LV, p. 168, 1912. (Euphæa).

5. **Polythorinæ.** Figs. 16-27. *Miocora, Cora, Euthore, Polythore, Chalcopteryx.*

Miocora and *Cora* are the most generalized genera. This and the preceding family form a short lateral branch at the base of the Agrionid tree characterized by ventral gills in the naiad.[12] The peculiar arculus is not primitive but is derived from a normal arculus as is shown by the position of its upper end in the angle formed by M_4. *It has been pulled into this illogical position by the shortening of the upper limb of the arculus.*

The ventral abdominal gills are considered by the writer to be specialized and not archaic, *i. e.*, they do not hark back of the Zygoptera to Ephemerid gills or the like. The primitive method of breathing in the Odonate orders seems to have been rectal because that is the method in the Anisoptera and in the first two instars in Zygopterous naiads. Also any Zygopterous naiad lives normally by rectal breathing after the external gills have been removed. If this is true the caudal gills are a comparatively late acquisition which applies also to the ventral paired gills. The writer reasons that the slender stature of the adult Zygopter was reflected in the larva or developed there parallel, that with the diminishing diameter of the abdomen the rectal gill basket became crowded which necessitated the development of external gills. This development of external gills then took place along two lines. 1. Caudal and ventral gills in the Polythorine-Epallagine branch; and 2. Caudal gills in the other Zygoptera.

6. **Agrioninæ.** Figs. 42–73. *Caliphæa, Neocharis, (Dicterias), Heliocharis, Cyanocharis, Phaon, Vestalis, Lais, Hetaerina, Mnais, Psolodesmus, Climacobasis, Umma, Sapho, (Archineura), Agrion, Matrona, Matronoides, Neurobasis.*

The first eight are the primitive forms, while *Archineura, Matronoides* and *Neurobasis* are highly specialized in rich venation and naiadal characters. *Caliphæa* shows relationship to the *Epallaginæ* in the recurrent penis lobes, but to the primitive Agrionines, especially *Hetærina* and the South American series in its arculus and quadrangle. A study of the penes, figs. 48–53, at once showed the South American series of *Neocharis, Heliocharis* and *Cyanocharis* to be Agrionine. These are in South America where primitive genera might be expected and again

[12] Calvert, Ent. News, XXII, pp. 49–64, 1911. (Cora).

connect the broad-winged specialized Oriental genera with the petiolate primitive subfamilies. *Lais* and *Hetærina* are a primitive side line in which two of the penis lobes are usually lost. The nymphs of this subfamily are very specialized in the deeply cleft labium and in the stalked antennæ. One such from South America, probably of the *Neocharis* series, is in Williamson's collection, while those of *Phaon*,[13] *Vestalis*,[14] *Hetærina*[15], *Agrion*,[16] *Matrona*,[17] *Neurobasis*,[18] have been described. One glance at the labium of *Neurobasis* will convince the most skeptic that it is highly specialized with its profound cleft and long spines.

7. **Libellaginæ.** Figs. 74–81. *Micromerus*, *Libellago*, (*Rhinoneura*), *Rhinocypha*, (*Disparocypha*).

The unspecialized penes in this group are in *Micromerus*, Figs. 80–81, and in the plain-winged Rhinocyphas, Figs. 78–79. These insects are small with primitive black-tipped wings. The specialized penes with elaborate lobes occur in those large *Rhinocyphas* with pictured wings. This indicates that the primitive Libellagine insect was smaller than the average pictured winged *Rhinocypha* of today and that it has a two-lobed penis similar to those of the Epallaginæ, also that its wings had the very generalized black tips common in Agrionidæ. The stalked antennæ of the naiads of *Libellago*[19] and *Micromerus*[20] indicate some relationship to the Agrionidæ. Here curiously enough we have the short, wide body correlated with rectal breathing. See page 23.

8. **Platystictinæ.** Penes not figured[21] but two lobed and resembling those of the *Epallaginæ* and *Megapodagrioninæ*. *Platysticta*, *Palæmnema*, (*Protosticta*).

If Fraser[22] has correctly identified his exuvium as *Protosticta* then this series surely goes here being exceedingly reduced forms probably derived from a Megapodagrionine stock. The writer before seeing Fraser's figures had thought

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[13] Karsch. Die Insecten der Berglandschaft Adeli, p. 48, 1893. (Phaon?)
[14] Ris Tijdsch. v. Ent. LV, p. 177, 1912.
[15] Needham, N. Y. State Mus. Bull. 68 p. 227, 1903.
[16] Hagen, C. R. Soc. Ent. Belg. 23 pp. LXV–LXVII, 1880.
[17] Fraser, Rec. Ind. Mus. XVI, p. 463, 1919.
[18] Needham. Ent. News, XXII, p. 147, 1911.
[19] Karsch, Insect. Berglandschaft Adeli, p. 48, 1893.
[20] Fraser, Rec. Ind. Mus. XVI, p. 197, 1919.
[21] Kennedy. Ent. News, Julp. 1917. Figs. of penes of Palæmnema and Platysticta.
[22] Fraser, Rec. Ind. Mus. XVI, p. 465, 1919.

this group a remote relative of the Psendostigmatinæ because of the regular venation, the penes, and the male appendages. Dr. Calvert possesses nymphs of *Palæmnema* which should settle the matter.

II. Hemiphlebidæ.

9. **Hemiphelbinæ.** Penis not figured but has characters of the *Megapodagrioninæ*, *Lestidæ*, and *Cænagrioninæ*. *Hemiphlebia.*

Because of the singular penis and male claspers this could be associated with no group in the *Cænagrionidæ*. Its irregular cross veins suggest the *Agrionidæ*. It certainly has no near relatives among the known *Odonata*. Its location in Australia is highly suggestive of a very ancient stock.

III. Lestidæ.

This family is characterized by the cleft labium of the naiad, the regular gizzard patches without specialized large teeth, the penis lacking the terminal lobe, the male appendages and the occurrence of an oblique cross vein between R_s and M_3 distad of the subnodus.

10. **Perilestinæ.**

Penis not figured but truly Lestid in that it lacks the terminal segment. Male appendages and gizzard Lestid. The writer suggests the following as a possible explanation of the long bridge in this family. The ancestral Lestid may have been an attenuate insect like *Perilestes*. When the other subfamilies were developed from this by increasing the area of the wings to sustain the heavier body the other forks retreated basad but left the fork of R_s behind in the apical half of the wing where it occurs normally in *Perilestes* because in this case it has never moved back.

11. **Synlestinæ.** Figs. 10–15. *Synlestes*, *Chlorolestes.*

These appear to be true Lestids. Tillyard[23] has shown them to be Lestid by venation. The penes lack the terminal segment and the patches in the gizzard occur in fours while they are armed with fine teeth only, as in the other two subfamilies. The naiad[24] has a cleft labium but has generalized gills, which

[23] Proc. Linn. Soc. N. S. W. 39, p. 193, 1914.

[24] Tillyard, Biology of Dragonflies, p. 83, Fig. 32 G., 1917.

would seem to connect the specialized *Lestinæ* with the primitive members of the *Agrionidæ*.

12. **Lestinæ.** Figs. 1–9. *Megalestes, Austrolestes, Lestes, Archilestes.*

The naiads with their highly specialized gills and labia as well as gizzards show this to be a group much more specialized than the venation would indicate. The position of the oblique vein beyond the subnodus shows that something unusual has happened in the development of this wing. *It surely has not developed* to its present form *over the same course* as that which must have been followed by *Hypolestes*, for instance, otherwise the oblique vein would not be where it is. The latest and most specialized forms in this group are the two species of *Archilestes*. *Megalestes* is the most aberrant member of the series and may be a connecting link between the Synlestinæ and Lestinæ.

IV. Cœnagrionidæ.

This family is distinguished at once from all the preceding by the fact that the naiad has no median cleft in the middle labial lobe. The penes always have the last segment present. The shaft spines when present are never long or heavy as in many Agrionid genera. Except in the *Psendostigmatinæ* there are seldom extra sectors other than M_{1a}.

(8. **Platystictinæ?**)

The writer does not have any conclusive data to show where this subfamily belongs. See subfamily 8 under *Agrionidæ*.

13. **Psendostigmatinæ.** Penes not figured but distinctly *Cœnagrionid*.

Dr. Calvert[25] has shown by the naiad that these are truly Cœnagrionid. The stalked caudal gills in *Copera*[26] and *Mecistogaster* may indicate relationship. The penes show that the small forms, *Mecistogaster jocaste* and *ornatus* are generalized and are the forms connecting to the Cœnagrionid stem, while *Microstigma* and *Megaloprepus* are the most specialized.

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[25] Ent. News. 22, p. 449, 1911.
[26] Fraser, Rec. Ind. Mus. XVI, p. 464, 1919.

14. **Platycneminæ.** Penes not figured. *Metacnemis, Allocnemis, Chlorocnemis, Prionocnemis, Copera, Platycnemis, Amphicnemis, Cœliccia, Pericnemis, Indocnemis Idiocnemis, Calicnemis, Stenocnemis.*

The labia of *Copera*[27], *Platycnemis*[28] and *Calicnemis*[29] are of the uncleft Cœnagrionid type, while the peculiar stalked gills of *Copera*[25] are remarkably like those in *Mecistogaster*[30]. The penes do not indicate any close relationship to the *Protoneurinæ*. The genera fall into two groups: An Eurafrican group and an Oriental group.

15. **Protoneurinæ.** Penes not figured. (*Proneura*), *Peristicta, Neoneura, Idioneura Microneura, Protoneura, Epipleoneura, Epipotoneura, Phasmoneura, Psaironeura, Neosticta, Austrosticta, Isosticta,* (*Oristicta*) *Chloroneura, Disparoneura, Indoneura, Nososticta, Notoneura, Risioneura.*

These are probably reduced Cœnagrionids though the penes in the less reduced forms are Agrionid-like and the naiads are queer in being Agrionid in some characters and apparently Cœnagrionid in others. Only the naiad of *Chloroneura*[31] has been well described.

The penes of the *Disparoneura* series as well as of the primitive South American *Peristicta* are four lobed and could be classed (on penis characters alone) among the Agrionid penes. Some species of *Disparoneura* and *Caconeura* have penes[32] almost identical with those of *Amphipteryx*, figs. 86–87, and *Hypolestes*, figs. 88–90. It is yet possible that a study of the naiads will show a part or all of the *Protoneurinæ* to belong in the Agrionid series of subfamilies.

16. **Cœnagrioninæ.**

Penes not figured but of diverse types in which there are seldom the elaborate lobes found in many Agrioninæ, and in which the shaft is never completely covered with hairs as in the *Megapodagrioninæ*. This subfamily contains approximately seventy genera, which are too many to list here.

The writer considers its older genera to be little later in origin than the older *Agrionidæ*. The current confusion in the

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27 Fraser, Rec. Ind. Mus. XVI, p. 464, 1919.
28 Rousseau, Ann. Biol. Lacustre, III, p. 352, 1909.
29 Fraser, Rec. Ind. Mus. XVI, p. 465, 1919.
30 Calvert, Ent. News, 22, p. 455, 1911.
31 Fraser, Rec. Ind. Mus. XVI, p. 466, 1919.
32 Kennedy, Ent. News, XXVIII, Pl. XXI, Figs. 9–17, 1917.

classification is due to two things: 1, The attempt to show phylogeny by venation which is hopeless because of the numerous convergences; and 2, The failure to recognize that there are four major series and not three as outlined by de Selys. These are:

1. The ARGIA series with long leg spines, the most generalized members of which are *Onychargia* and *Diargia* and which has developed through *Argia* into the giant *Hyponeura*.

2. The CŒNAGRION-PSEUDOGRION. These have short tibial spines, females without a vulvar spine and have a rounded frons. These start with such genera as *Erythromma* and *Cercion* and end in the large modern genera mentioned above.

3. The ENALLAGMA-ACANTHAGRION series. This series is characterized by short tibial spines, rounded frons, females with a vulvar spine. This splits into two series on the nature of the male appendages.

(a) The *Enallagma* series with forked appendages.

(b) The *Acanthagrion* series with the dorsal appendages slanting downward.

4. The NEHALENNIA-TELEBASIS series. These have short tibial spines, females without vulvar spine, and have an *angulate frons*. This is the series that has been heretofore mixed through the first three series with interminable confusion. The penes are characteristic in many of the species of this series which indicates its validity. This falls into two distinct series.

(a) The CHROMAGRION-NEHALLENIA-TEINOBASIS series with appendages that have a large basal spine.

(b) The CERIAGRION-TELEBASIS-METALEPTOBASIS series in which the appendages do not have a well developed basal spine.

The curious *Argiallagma* of Florida and Cuba has characters of series 1, 3 and 4 and appears to be a very ancient insect.

EXPLANATION OF PLATES I, II AND III.

LESTINÆ—

Figs. 1–2. *Megalestes major* Selys. Kooloo, Carleton.
Figs. 3–4. *Archilestis grandis* (Rambur). Tucson, Ariz.
Figs. 5–6. *Lestes disjunctus* Selys. Bluffton, Ind.
Figs. 7–8. *Austrolestes cingulatus* (Burm.) Victoria, Australia.
Fig. 9. *Austrolestes tenuissimus* Tillyard. Cooktown, Australia.
Figs. 10–11. *Chlorolestes conspicua* Selys. (S. Africa).
Figs. 12–13. *Chlorolestes tessallata* (Burm.). (S. Africa).
Figs. 14–15. *Synlestes weyersi* Selys. Victoria, Australia.

THORINÆ—
Figs. 16–17. *Thore gigantea* Selys. St. Fe de Bogata, Lindig, 1862.
Figs. 18–19. *Miocora* sp. Columbia.
Figs. 20–21. *Cora cirripa* Calvert. Carillo, Costa Rica.
Figs. 22–23. *Cora marina* Selys. Panima, Guatemala.
Figs. 24–25. *Euthore fasciata inlactea* Calvert. Peru.
Figs. 26–27. *Chalcopteryx rutilans* (Rambur). Matto Grosso, Brazil.

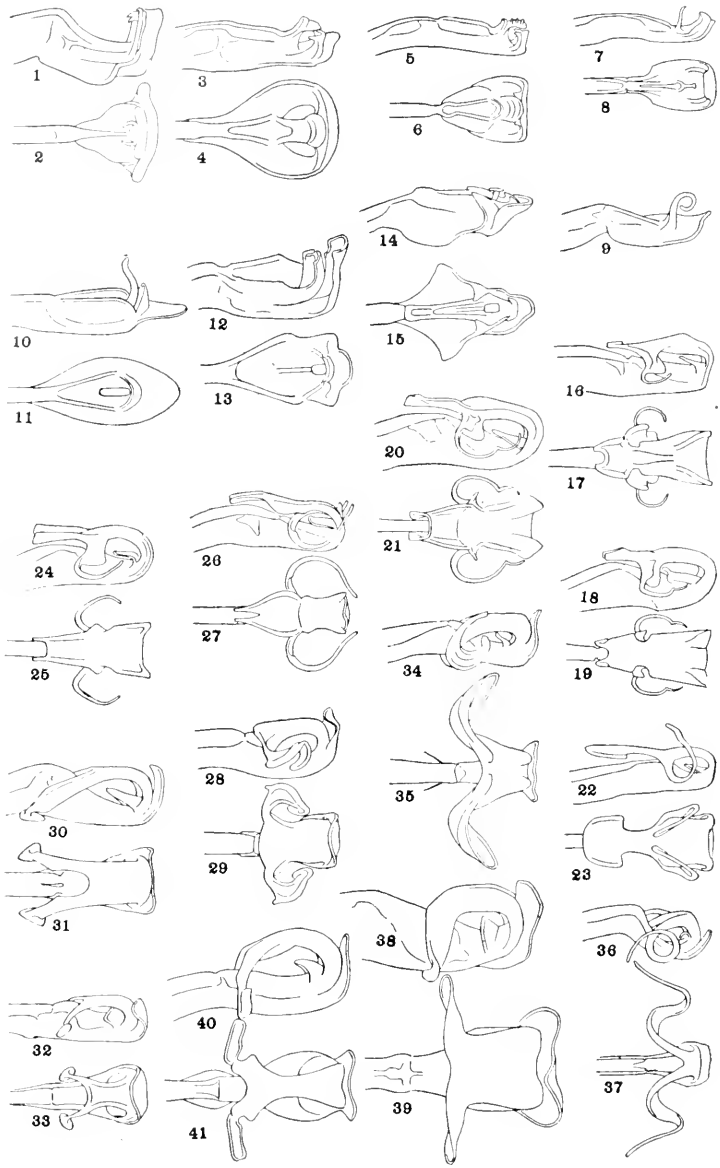
EPALLAGINÆ—
Figs. 28–29. *Epallage fatima* (Charp). Asia Minor.
Figs. 30–31. *Bayadera indica* (Selys). Anam.
Figs. 32–33. *Dysphæa lugens* Selys. Borneo. (See Figs. 40–41).
Figs. 34–35. *Euphæa splendeus* Selys. Ceylon.
Figs. 36–37. *Anisopleura comes*. Hagen, India.
Figs. 38–39. *Philoganga* sp. Sarawak, India.
Figs. 40–41. *Dysphæa limbata* Selys. (See Figs. 32–33.)

AGRIONINÆ—
Figs. 42–43. *Hetærina sanguinea* Selys. (This penis like some species of *Lais*.)
Figs. 44–45. *Hetærina fuscibasis* Calvert. Chapada, Brazil. (This penis like that of *Lais pudica*).
Figs. 46–47. *Vestalis amæna* Selys. Borneo.
Figs. 48–49. *Heliocharis amazonica* Selys. Chapada; Brazil.
Figs. 50–51. *Cyanocharis valga*. Needham (S. Amer.).
Figs. 52–53. *Neocharis cothurnata* Fœrster. Tumatumari, Brit. Guiana.
Figs. 54–55. *Phaon iridipennis* (Burm.) Usambara, Africa.
Figs. 56–57. *Climacobasis modesta* (Laidlaw). Lower Siam.
Figs. 58–59. *Mnais andersoni* McLachlan. Burma.
Figs. 60–61. *Psolodesmus dorothea* Willsm. Formosa.
Figs. 62–63. *Sapho ciliata* (Fabr.) Togo, Bismarksburg, Africa.
Figs. 64–65. *Umma longistigma* (Selys). Camerun, Africa.
Figs. 66–67. *Agrion mingrelica*. Kobaletz, (Caucasus?).
Figs. 68–69. *Matrona basilaris* Selys. Shanghai, China.
Figs. 70–71. *Neurobasis kaupi* Brauer. Celebes.
Figs. 72–73. *Matronoides cyaneipennis* Foerster.

LIBELLAGINÆ—
Figs. 74–75. *Libellago caligata* Selys. Natal.
Figs. 76–77. *Rhinocypha angusta* Selys. Sumatra.
Figs. 78–79. *Rhinocypha eximia* Selys. Celebes.
Figs. 80–81. *Micromerus stigmatizans* Selys. Mt. Ophir. (Malacca?).

AMPHIPTERYGINÆ—
Figs. 82–83. *Devadatta argyroides* (Selys). Sarawak.
Figs. 84–85. *Diphlebia lestoides* (Selys). Lilyvale. N. S. W., Australia.
Figs. 86–87. *Amphipteryx agrioides* Selys. S. Geronimo, Guatemala.
Figs. 88–89. *Hypolestes* (*Ortholestes*) *clara* Calvert. Kingstown, Jamaica.
Fig. 90. *Hypolestes* (*Ortholestes*) *abbotti* Calvert. Santiago, Cuba.

MEGAPODAGRIONINÆ—
Figs. 91–92. *Thaumatoneura inopinata* McLachlan. Costa Rice.
Figs. 93–94. *Paraphlebia quinta* Calvert. Guatemala.
Figs. 95–96. *Rhipidolestes aculeata* Ris. Formosa.
Figs. 97–98. *Argiolestes grisea* Selys. Australia.
Figs. 99–100. *Argiolestes icteromelas* Selys. Queensland, Australia.
Figs. 101–102. *Argiolestes alpinus* Tilly. Australia.
Figs. 103–104. *Wahnesia montivagans* Fœrster. Sattelberg.
Figs. 105–106. *Podopteryx roseonotata* Selys. Aru Islands.
Figs. 107–108. *Neurolestes trinervis* Selys. (Cameroons).
Figs. 109–110. *Nesolestes alboterminata*, Victoria, Australia.
Figs. 111–112. *Podolestes orientalis* Selys. Borneo.
Figs. 113–114. *Philogenia terraba* Calvert. Costa Rica.
Figs. 115–116. *Megapodagrion mercenarium* (Hagen). St. Fe de Bogata.
Figs. 117–118. *Allopodagrion contortum* (Selys) Brazil.
Figs. 119–120. *Dimeragrion percubitale* Calvert. Brit. Guiana.
Figs. 121–122. *Rhinagrion macrocephala* (Selys). Labauan.
Figs. 123–124. *Heteragrion flavidorsum* Calvert. Bolivia.



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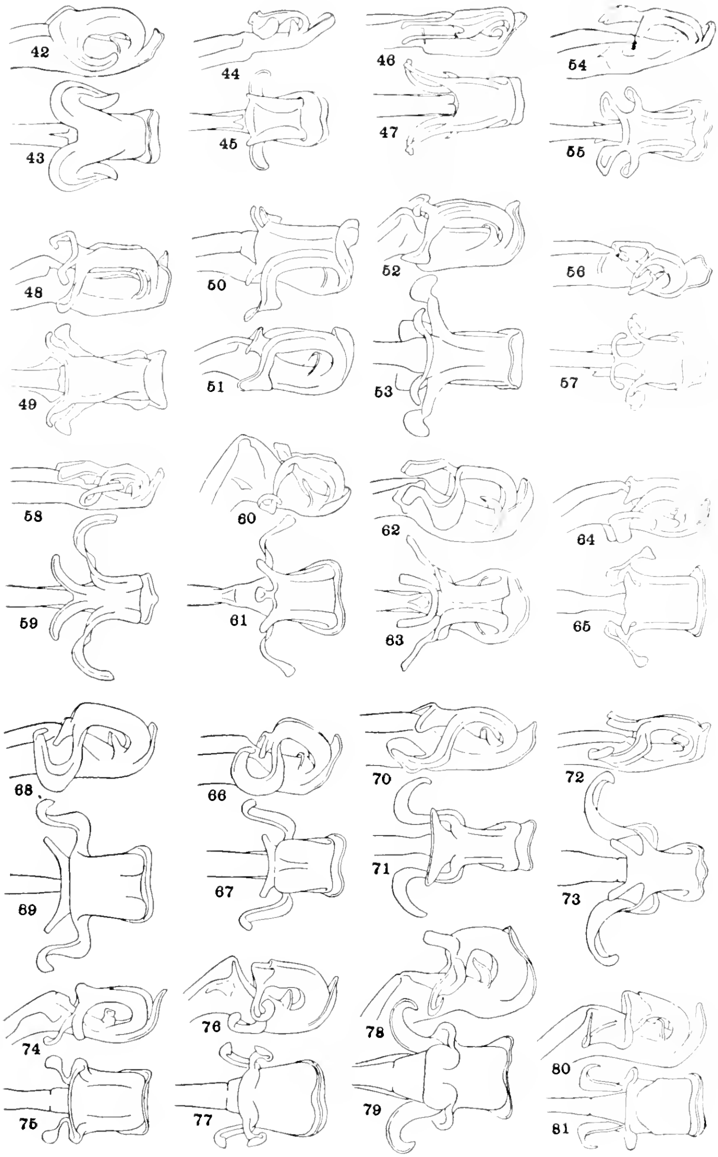

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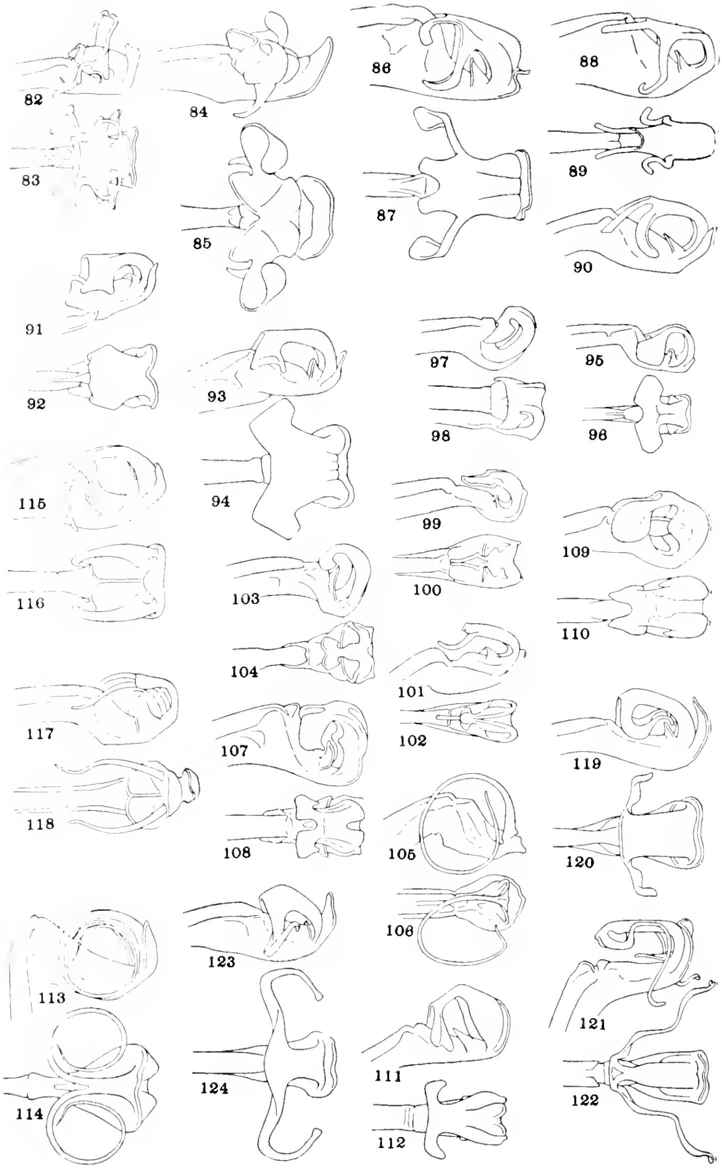
PLATE III



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RACINE AND CEDARVILLE CYSTIDS AND BLASTOIDS WITH NOTES ON OTHER ECHINODERMS.

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No adequate study of the cystids of the Cedarville dolomite of Ohio ever has been undertaken. In Volume III of the Report of the Geological Survey of Ohio, published in 1876, *Caryocrinites ornatus*, *Gomphocystites glans*, *Hallicystis imago*, and *Holocystites abnormis* are listed from Bierley's quarry, along the creek four and a half miles east of Greenville, in Darke County, Ohio. On page 417 of the same volume *Holocystites cylindricus* is included in the list of fossils from the Niagara group, but no locality is mentioned. However, of the species cited, *Caryocrinites ornatus* is restricted to the Rochester shale of New York and the adjacent parts of Canada, and, although several species of *Caryocrinites* occur in the Cedarville dolomite of Ohio, none of these belong to the Rochester form, all being undescribed so far. *Gomphocystites glans*, moreover, is a Racine species with an elongated stipe, whereas all of the specimens of *Gomphocystites* found so far in the Cedarville dolomite of Ohio have short stipes. *Hallicystites imago* is represented by typical specimens from Springfield, Ohio. Forms resembling *Holocystites abnormis* and *H. cylindricus* also are present in the Cedarville dolomite of Ohio, but have not yet been studied with sufficient care to insure their identity. On the other hand, *Holocystites alternatus* is represented by characteristic specimens from several localities in Ohio, and a primitive species of *Holocystites* was described recently (OHIO JOUR. SCIENCE, 17, p. 203, pl. 9, figs. 3 A, B, C; pl. 10, fig. 8) under the name *Holocystites greenvillensis* Foerste. In the same paper two cystids were described under the terms *Callocystites jewetti elongata* Foerste and *Callocystites sphæroidalis* Foerste. Recent investigations have shown, however, that the latter species is founded on the exterior of *Cœlocystis subglobosus*, a species already described from the Racine dolomite, the latter being founded on casts of the interior of the theca.

Most cystids from the Cedarville dolomite of Ohio evidently are related closely to those of the Racine dolomite of Wisconsin and Illinois, described by Hall in 1868 in the 20th Report of the New York State Cabinet of Natural History. Several of these Racine species were restudied by Schuchert in his paper on *Siluric and Devonic Cystidea and Camarocrinus*, published in the 47th volume of the Smithsonian Miscellaneous Collections in 1904, but some of the other Racine species demand equally detailed consideration and the results of recent studies on several of these species are incorporated here.

As a result of these studies we now know the appearance of the exterior of the theca of *Cœlocystis subglobosus* (Hall). It has been learned that *Aethocystites* and *Lysocystites* are identical genera, the former being founded on the exterior of one species, and the latter on the interior of a second species, but both species are congeneric. *Crinocystites chrysalis,* moreover, has been identified as the anal tube of some species of *Eucalypto-crinus*.

It is now recognized that the figures accompanying the original descriptions of *Lysocystites nodosus* and *Crinocystites chrysalis* were drawn in inverted positions. After some difficulty it has been found possible to diagram the plate system of the type of *Cœlocystis subglobosus*, confirming the identifications made by Schuchert, and considerable variation has been observed in the general form of different specimens and in the outlines, arrangement, and number of the plates. In *Holocystites alternatus*, the intercalation of supplementary plates has been made the subject of further study.

Only one species of blastoids is known from the Cedarville dolomite of Ohio, *Troostocrinus subcylindricus* (Hall and Whitfield), published in 1875, in volume 2 of the Paleontology of Ohio. The occurrence of *Troostocrinus* is noted also in the Racine of the Chicago area, the Bainbridge of eastern Missouri, and the top of the Laurel limestone of southeastern Indiana.

The Ohio species, *Eucalyptocrinus proboscidialis* Miller, is refigured to show its close relationship to *Crinocystites chrysalis* Hall.

The problematical organisms described as *Cyclocystoides*, and usually regarded as *Edrioasteroids*, show variations in structure suggesting the presence of several groups of generic ank, and for two of these groups the terms *Narrawayella* and *Savagella* are proposed here.

A new genus of cystids, evidently closely related to *Amygdalocystites*, from the Kimmswick limestone of southeastern Missouri, is named *Wellerocystis*.

LIST OF SPECIES.

Cystoidea.

Malocystidæ.

1. *Wellerocystis kimmswickensis* Gen. et sp. nov.
   Comarocystites and Echinosphærites in Kimmswick strata.

Callocystidæ.

2. *Hallicystites imago* (Hall).
3. *Callocystites jewetti elongatus* Foerste.
4. *Cœlocystis subglobosus* (Hall).

Cryptocrinidæ.

5. *Lysocystites sculptus* (Miller).
6. *Lysocystites nodosus* (Hall).

Sphæronitidæ.

7. *Holocystites alternatus* Hall.
8. *Holocystites greenvillensis* Foerste.
9. *Allocystites hammelli* Miller.

Gomphocystidæ.

10. *Gomphocystites indianensis* Miller.
11. *Gomphocystites* sp. (From the Louisville limestone.)
12. *Gomphocystites bownockeri* Sp. nov.

Edrioasteroidea.

Cyclocystoididæ.

Narrawayella Gen. nov.
Narrawayella raymondi Sp. nov.
Savagella Gen. nov.

13. *Savagella ornatus* Savage.
14. *Cyclocystoides* (?) *illinoisensis* Miller and Gurley.

Blastoidea.

Troostoblastidæ.

15. *Troostocrinus sanctipaulensis* Sp. nov.
16. *Troostocrinus reinwardti minimus* Var. nov.
17. *Troostocrinus subcylindricus* (Hall and Whitfield).
18. *Troostocrinus* sp. (From the Racine dolomite.)

Crinoidea.

Calyptocrinidæ.

19. *Crinocystites chrysalis* Hall.
    Eucalyptocrinus proboscidialis Miller.
    Eucalyptocrinus slocomi Sp. nov.
20. *Periechocrinus cylindricus*. Foerste.

Wellerocystis Gen. nov.

Amygdalocystites and Canadocystis.—The genera *Amygdalocystites* and *Canadocystis* agree in having two divergent main food-grooves which curve toward their distal ends in a more or less distinctly dextral direction. These food-grooves are supported on single series of plates, which rise more or less abruptly along the convexly curved outer side of the rays and which support on this side a single series of brachioles, while the main food-grooves occupy the concavely curved side of the rays. In both genera, the anal opening lies exterior to the convexly curved side of the nearest one of the two rays, but near a vertical plane passing through the oral aperture and parallel to the proximal straighter part of the rays.

Wellerocystis.—In a cystid found by Prof. Stuart Weller in the Kimmswick limestone of eastern Missouri a closely similar structure is found. Its general aspect is nearest that of *Amygdalocystites*, but there are 3 instead of 2 rays, that one of the primary rays which is most distant from the anal opening branching within a short distance from the oral aperture, the new branch being added on the left side of the primary ray. Moreover, the anal opening, as exposed in the type specimen, lies within the area enclosed by the concavely curved side of the undivided ray. From *Amygdalocystites* this cystid differs in its ovoid form, and in the absence of radiate ribbing on the thecal plates, the latter being gently convex and minutely granular. From *Canadocystis* it differs in the different location of its anal opening, in the branching of one of its rays, and in the more decurrent growth of the tips of these rays. However, if the Kimmswick specimen be so oriented that its anal opening is on the same side as in *Canadocystis*, then the attachment area for the column in both cases will be found on the diagonally opposite side of the basal part of the theca.

Genotype.—*Wellerocystis* kimmswickensis Sp. nov. Genus named in honor of Prof. Stuart Weller, in recognition of his many important contributions to American Paleontology. Genotype formed by the Kimmswick cystid mentioned above.

In the United States National Museum at Washington there is another undescribed Kimmswick cystid, collected by Dr. E. O. Ulrich, apparently congeneric with *Wellerocystis* kimmswickensis, but with each of the two primary rays having two additional branches, thus forming a total of six.

Wellerocystis kimmswickensis Sp. nov.

(Plate 1, Figs. 12 A, B.)

Theca 20 mm. in height and 15 mm. in width, ovoid in form, with attachment area for column about 4 mm. from the vertical axis, on the side opposite to that occupied by the anal opening. Oral aperture at the summit of the theca, a millimeter long in a direction parallel to the proximal part of the main food-grooves, and about a quarter of a millimeter in width, the elongation being in a direction almost at right angles to a vertical plane passing through both the anal opening and the attachment area for the column. That one of the two primary rays

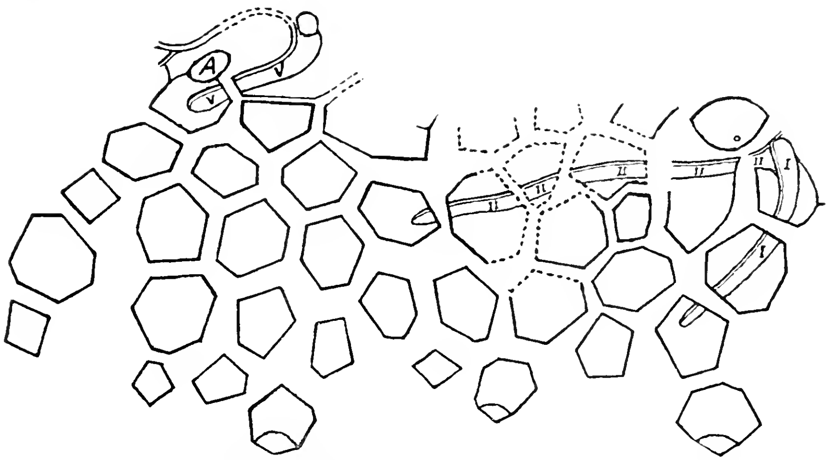


FIG. 1. Diagram showing the arrangement of the plates in *Wellerocystis kimmswickensis*.

The outlines of the plates in the apical region, between the rays, are very uncertain, but are indicated as well as they can be ascertained by means of dotted lines. The position of the anal aperture is at A. The three recumbent rays are numbered I, II and V. The food-grooves follow those sides of the rays which are marked by two closely placed parallel lines. The oral aperture is represented in the diagram by a circle at the upper end of ray V. The food-groove extending from the oral aperture toward the left connects with rays I and II. There are 3 basal plates, indicated by parts of a circle at their bases, the latter limiting the areas of articulation of these basal plates with the column.

which encircles the anal aperture remains unbranched and is only 10 mm. in length, measuring along its convexly curved side. The other primary ray, on the opposite side of the oral aperture, is 18 mm. in length; about 2.5 mm. from this aperture a branch of intermediate length is added on the left side of this second ray, thus forming a total of three rays. The number of brachioles supported by the ray encircling the anal aperture was about 5; the number on the other primary ray equalled about 7 or 8, and that on the branch of this second ray was about 10. Viewed directly from above, the food-grooves with their branches leading to the facets formerly supporting the brachioles resemble those

of *Canadocystis emmonsi*, but the general appearance of upper surface of the plates supporting the food-grooves is more convex. The madreporite and gonopore can not be identified with certainty.

Number of thecal plates, as far as can be determined from the single specimen at hand, about 40, arranged more or less irregularly, but with a tendency toward oblique rows parallel to the distal ends of the rays, apparently about 5 or 6 plates in a row, unless the number of apical plates is greater than can be determined from this single specimen.

Surface relatively smooth, without radiate folds as in *Amygdalocystites;* probably with minute granules.

LOCALITY AND HORIZON.—From the Kimmswick limestone at Glen Park, in Jefferson County, Missouri. Type numbered 10727 in Walker Museum at Chicago University.

REMARKS.—*Wellerocystis* presents combinations of characteristics found in *Amygdalocystites* and *Canadocystis*. However, since *Canadocystis* appears to be a less specialized type, it is probable that the relationship of *Wellerocystis* is closer to the latter genus. Little can be said about its relationship to *Malocystites* until the type of the genus, *Malocystites murchisoni* Billings becomes better known. Billings stated that the two primary rays of this species branched so as to produce two sets of branches, 4 in each set, and he figured the supporting plates of these branches as uniserial, but so unlike those of *Amygdalocystites* and *Canadocystis* in appearance that close relationship remains in doubt.

COMAROCYSTITES AND ECHINOSPHAERITES IN KIMMSWICK STRATA.

In the United States National Museum at Washington there are specimens of *Comarocystites shumardi* Meek and Worthen and of a species of *Echinosphaerites* resembling *E. aurantium* (Gyllenhal), which were obtained by Dr. E. O. Ulrich in the railroad cut half a mile south of the station at Thebes, Illinois, in the upper part of the Kimmswick formation, above the more richly fossiliferous part of the Kimmswick section whose fauna was investigated by Savage in detail. This occurrence indicates that the cystids named belong at the top of the Kimmswick formation and not at its base (Denison Univ. Bull. 19, 1920, pp. 179, 180, 181, 184, 196). At Thebes they are associated with a species closely resembling *Wellerocystis kimmswickensis*. There are two primary rays; that primary ray which is most distant from the anal opening branches on its left side, thus making a

total of three rays. The supporting plates for the rays are uniserial, and all brachioles are located on the left side of the rays, when the latter are held so that their proximal parts are nearest the observer. The chief difference of this new species of cystid of the Thebes locality from Wellerocystis appears to be in the character of its plates, the latter being coarsely radiate with bold cuneate ridges, much coarser than in *Amygdalocystites florealis*. The anal opening is located on the convexly curved side of the unbranched primary ray.

Dr. E. O. Ulrich has collected *Comarocystites shumardi* and *Echinosphaerites* cf. *aurantium* from the upper Kimmswick also at Cape Girardeau, Missouri. *Wellerocystis kimmswickensis* probably belongs to the same horizon but was found farther north in Missouri, in Jefferson County. No trace of this upper Kimmswick fauna has been found so far in northeastern Missouri, in Ralls or Pike Counties.

2. **Hallicystis imago** (Hall).

(Plate I, Figs. 7, 8; Plate II, Figs. 7 A, B, C.)

Apiocystites imago Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 314, Pl. 12, Fig. 12, Pl. 12a, Fig. 9.

Hallicystis imago Jaekel, Stammesgeschichte d. Pelmatozoen, 1, Thecoidea u. Cystoidea, 1899, p. 288, Pl. 15, Fig. 3.

Hallicystis elongata Jaekel, Idem, p. 288.

Hallicystis imago Foerste, Ohio Jour. Sci., 17, 1917, p. 235, Fig. 1; Pl. II, Fig. 2.

Typical *Hallicystis imago* seems to be characterized by an attenuate base for the attachment of the column, the attachment area being small compared with that of *Callocystites jewetti-elongatus*. The pectinirhombs appear to be narrow with relatively few dicho-pores. These features are shown even by the smallest, and presumably youngest, specimens (Plate I, Fig. 8) at hand.

Hallicystis elongatus appears to be a broader form, less attenuate at the base, with the anus occupying a relatively lower position; the pectinirhombs are conspicuously larger, and the dichopores on plates 14–15 number about 14, which is distinctly more than in typical *Hallicystis imago*.

It has not yet been determined whether these forms are distinct species or merely variations of the same species. This will require a sufficient number of specimens to determine their range of variation.

Locality and Horizon.—From the Racine dolomite at Racine, Wisconsin, and in the Chicago area, in Illinois. Also from the Cedarville dolomite at Cedarville, Ohio.

3. **Callocystites jewetti-elongatus** Foerste.

(Plate II, Fig. 6.)

Callocystites jewetti-elongata Foerste, Ohio Jour. Sci., 17, 1917, p. 236, Fig. 2, Pl. II, Figs. 6 A, B.

Base of cast of interior of the theca, showing a faint tendency toward a quadrate outline owing to faint ridges connecting middle points of the four basals. The area of attachment for the column is relatively large. Compare with basal view of *Hallicystis imago* (Hall).

Locality and Horizon.—From the Cedarville dolomite at Cedarville, Ohio.

4. **Cœlocystis subglobosus** (Hall).

(Plate I, Figs. 1 A, B. Plate II, Figs. 1 A, B; 2 A, B; 3 A, B, C; 4; 5 A, B, C, D; 6.)

Hemicosmites subglobosus Hall, 20th Rep. New York State Cab. Nat. Hist., 1870, p. 359, Pl. 12, Fig. 13.
Sphærocystites dolomiticus Jaekel, Stammesgeschichte der Pelmatozoen, 1899, p. 289, plate diagram 63.
Cœlocystis subglobosus Schuchert, Smithsonian Misc. Coll., 47, 1904, p. 248, plate diagrams 36, 37.
Callocystites sphæroidalis Foerste, Ohio Jour. Sci., 17, 1917, p. 238, Fig. 3; Pl. 12, Fig. 5.

Type figured by Hall.—The type figured by Hall is numbered 2027 in the American Museum of Natural History in New York City. It was obtained in the Racine dolomite at Racine, Wisconsin. This type never has been adequately figured or described, though the necessity for this has been removed largely by the excellent plate diagrams and descriptions published by Prof. Schuchert as the result of studies based on material from the same horizon but from the Chicago area.

The type figured by Hall (Plate II, Figs. 1 A, B) is a cast of the interior of an abnormal specimen, lacking Plate 11. Possibly plates 16 and 11 are represented by a single plate in which the two component plates no longer can be differentiated. In the latter case, plate 11 may be regarded as attached to plate 16 and also as diminished in size and lifted in position, thus changing the outlines of the surrounding plates 5, 6 and 17, and affecting even the more distant plates 12 and 18. The upper part of the theca has been depressed obliquely along plates 9, 10, 15, 16 and 22, causing the circumoral part of the theca to be pushed backward, and producing a corresponding distortion of all of the lateral plates. The anal aperture, being situated on the right of the sagittal place passing through the mouth, hydropore, and aboral pole, lies within one of the areas of maximum distortion, the upper part of the surrounding plates inclining strongly backward. Plates 23 and 13 have weathered away. The most important difference from normal specimens consists in the small width and slight depth of the invaginated part of the base of this cast of the interior.

In normal specimens (Plate II, Fig. 5 C), the base of the cast of the interior of the theca is broadly, deeply, and quadrangularly invaginated.

The angles of the quadrangular outline of the invaginated part are strongly rounded, and terminate along the median line of the four basal plates. Measured diagonally across the invaginated area, from one angle to that diagonally opposite, the longer diameters of this area vary usually from 14 to 16 mm.; the depth of the invagination usually is only 2 or 3 mm., but may equal 4 mm. occasionally.

Jaekel, in diagramming that specimen of *Cœlocystis subglobosus* for which he proposed the name *Sphærocystites dolomiticus*, also found one plate missing, only one plate occurring in the area where usually the two plates 9 and 10 should occur. Plates 11 and 5 appeared to have enlarged, crowding the single plate representing both plates 9 and 10 toward the left. In consequence, the outlines of several plates have been altered considerably. Plate 4 has an angular top, and plate 15 has a corresponding angular base.

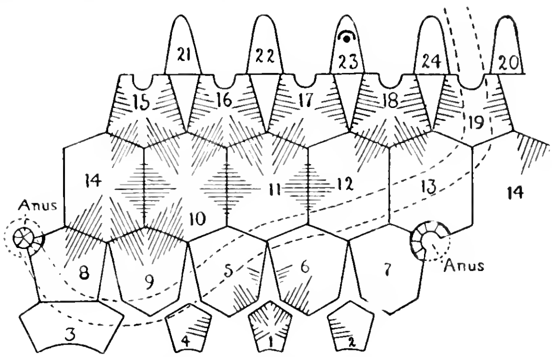


FIG. 2. The actual distribution of all pore-rhombs known with certainty in the *Glyptocystidæ,* showing how a space is left clear where the gut may be supposed to have pressed against the thecal wall. Copied from Bather, in Caradocian Cystidea from Girvan, 1913, page 437.

If the gut, pressing against the interior of the thecal wall, followed a path across plates 13, near the sutures between plates 18 and 12, 17 and 6, 11 and 5, across plates 10 and 9, the lower part of 14 and the middle of 8, to the anal aperture, then in many abnormal specimens showing reductions in the size and number of plates or changes in outline, these changes are more frequent along the supposed path of the gut. (Bather, Echinoderma, 1900, p. 58, fig. 20).

An entirely different type of abnormality is represented by the second specimen of *Cœlocystis subglobosus* (Plate II, Figs. 5 A, B, D; Schuchert, loc. cit., fig. 37) diagrammed by Schuchert. In this case the upper part of the theca is enlarged by the introduction of four accessory plates, numbered 15′, 16′, 18′, and 21′, by Schuchert. The first three of these accessory plates belong to the fourth primary circle of thecal plates which includes plates 15, 16, 17, 18 and 19. The accessory plate 21′ belongs to the fifth or circum-oral circle. In each case the accessory plate is assumed to have been added on the left side of the corresponding primary plate, as though something had dragged the primary plates

under consideration toward their right, or in a counter-clockwise direction. These changes have been accompanied by an increase in the height of the theca and a steepening of its lateral walls. The column, at its contact with the base of the theca, has a diameter of 6.5 mm.

In a specimen numbered 1603 (Plate II, Fig. 4), belonging to the Illinois State Museum of Natural History, from the Racine dolomite at Racine, Wisconsin, the lateral diameter of the theca is distinctly narrower than the one from front to rear, the theca is rather high, and the circum-oral parts have been pushed strongly forward, therefore, in a direction opposite to that shown by the type of *Cœlocystis subglobosus*.

Ohio specimens.—In Ohio, *Cœlocystis subglobosus* is known from the Cedarville dolomite both from Cedarville, and from the Moodie quarry at Wilmington.

The Cedarville specimen (Plate II, Figs. 3 A, B, C) is low and broad, with only a faintly invaginated base, but otherwise does not differ from typical specimens from the Chicago area.

The Wilmington specimen (Plate II, Figs. 2 A, B) is a much taller specimen and also has a faintly invaginated base. Faint flexures on this cast of the interior of the theca suggest that ambulacra resembling those of *Callocystites* reached as low as the margin of the invaginated part of the base, branching at least once, at about the level of the anal aperture.

Apparently this species is remarkable, among *Glyptocystidæ*, for the number and variety of its possible variations.

Exterior of Cœlocystis subglobosus.—In the Cedarville dolomite at Springfield, Ohio, two casts of the exterior of a globose Callocystid have been found, one of which was described and figured under the name *Callocystites sphæroidalis* Fœrste (Ohio Jour. Sci. 17, 1917, p. 238, fig. 3; pl. 12, fig. 5). The second specimen (Plate II, Fig. 8 of the present paper) supplements the first by showing the pectinirhomb on plates 1–5, and by showing definitely that the rays branched more than once. The entire theca must have been at least 4 mm. wider than the figure, the missing parts not being preserved in the specimen. The column was very large, considering the relatively small size of the theca. The surface of the first specimen is granulose, there being a tendency toward the arrangement of the granules in rows, about 6 or 7 granules in a length of 5 mm. On parts of the specimen the arrangement appears to be in diagonally intersecting rows; on other parts the rows take the form of parallel ridges, the transverse rows not being in evidence. On the second specimen the ornamentation consists of sets of parallel short ridges, not well brought out in the accompanying figure, the sets on different sectors of the plates being directed in different directions. The granules are not in evidence except as elevations irregularly dotting the crests of the ridges. It can not be determined from our present knowledge whether these specimens represent two distinct species.

In the collections in Walker Museum at Chicago University there is a black wax cast (Plate I, Figures 1 A, B) in the same tray with a specimen of *Cœlocystis subglobosus*, numbered 22906, and labeled as coming from the Hindshaw collection, which was made at Chicago, Illinois.

Since the numbered specimen shows poor traces of the ambulacral system and the wax cast shows excellent evidence of the character of the latter it is assumed that it came from the same locality. The wax cast was made by pouring the wax into a natural mold of the exterior of a specimen, the cracks between the fragments of the matrix showing distinctly. It exposes the top of the specimen with its five ambulacral rays. The anal aperture is clearly defined, its margin protruding slightly. The right posterior ray branches just above the level of the anal aperture, the tips of the two branches reaching within 3 or 4 mm. from the attachment area of the column. The right anterior ray branches at about the same level, the tip of the right hand branch extending as far down as the others mentioned. The anterior ray is moderately distinct as far as its point of branching; its branches may have reached opposite sides of the pectinirhomb on plates 1–5. Only the proximal part of the left anterior ray remains. The left posterior ray is clearly defined for about two-thirds of the height of the theca downward, but a faint trace of its right-hand branch indicates that its tip reached within 5 mm. of the attachment area for the column. The right posterior ray shows clearly the short lateral branches of the food-grooves traversing the rays and their branches, but the attachment areas for the brachioles are not indicated. Lateral branches of the food-grooves, leading to the brachioles, are visible also on the right anterior and left posterior rays. Three or four lateral branches are seen on each side of the proximal or undivided parts of the rays, about 10 occurring on each side of the branches. The ornamentation of the surface is indistinctly preserved. The base of the specimen is not invaginated at all, as viewed from the exterior, but there is a faint quadrangular appearance there where the quadrangular margin of the deeply invaginated base of the cast of the interior should appear. It is evident that the invagination is a characteristic of the interior and is accompanied by an immense thickening of the thecal plates within this invaginated part.

This explains the absence of invagination also on the exterior of the base of the second specimen found at Cedarville, Ohio, here figured (Plate II, Fig. 8), which at first puzzled the writer.

The attachment area of the Chicago specimen just described is 9 mm. in diameter.

Locality and Horizon.—From the Racine dolomite at Racine, Wisconsin, and in the Chicago area of Illinois. Also from the Cedarville dolomite at Cedarville and Wilmington, Ohio.

Both in the Cedarville dolomite of Cedarville, Ohio, and in the Racine dolomite of the Chicago area, there is a small cystid, about 15 mm. in diameter, which appears to be a new species of *Cœlocystis*. The circum-oral plates or deltoids, forming the fourth row of the theca, are relatively large. The pectinirhombs on plates 12–18, and 14–15, and the plates surrounding the anal aperture are well defined, but the base is not well exposed in any of the specimens at hand.

5. **Lysocystites sculptus** (Miller).

Aethocystites sculptus Miller, N. Am. Geol. Pal., First App., 1892, p. 673, Fig. 1207; 18th Ann. Rep. Indiana Dep. Geol. Nat. Res., 1894, p. 264, Pl. 2, Fig. 2.

The types are preserved in the State Museum at Indianapolis, Indiana, and are supplemented by a well preserved specimen collected by Herrick E. Wilson at the type locality, St. Paul, Indiana; this supplementary specimen probably is in the Springer collection, in the U. S. National Museum, at Washington, D. C. All specimens were found in the upper layers of the Laurel formation. Only the exterior of the theca is well preserved, and this presents the following characteristics.

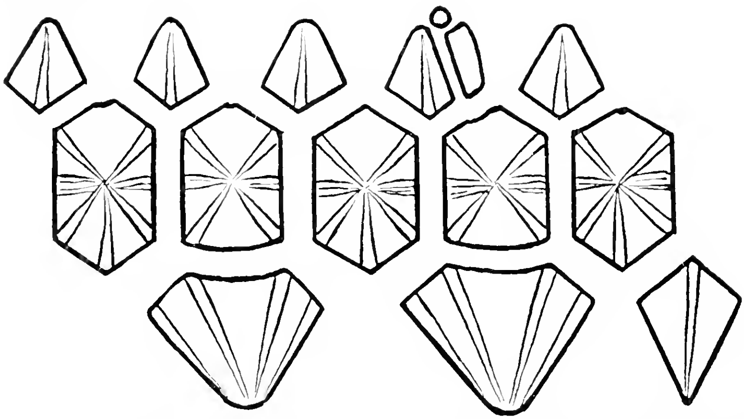


Fig. 3. Diagram showing arrangement of plates of *Lysocystites sculptus* (Miller). A composite drawing prepared from both the type and the specimen in the U. S. National Museum; not drawn to scale.

The basal series consists of three plates. Two of these are broad and are truncated above, evidently representing two plates each. The third plate is angular above. The genus evidently was derived from ancestral forms having five basal plates.

The second series consists of five plates, of which two are truncated at the base, all being angular at the top.

Alternating with the plates of the second series are five plates belonging to the third series. All of the latter are angular at the base and are medially ribbed. Beneath the anal aperture an elongated oblong plate appears to be inserted on the right side of one of the plates of this third series. The significance of this intercalated plate is not understood.

In each plate belonging to the second series, distally widening ribs radiate from the center to the upper and the two lower lateral corners, where they connect with corresponding vertical ribs on both the first and third series of plates. In addition, those three plates of the second series which are angular below have a fifth more or less distinct vertical rib connecting in each case with a rib following the sutures between the three basal plates. In the upper and lower quadrants of each plate of

the second series, vertical striae dominate; in the two lateral quadrants, horizontal striæ dominate. In all cases the dominating striæ are crossed transversely by finer striæ.

Nothing is known of the column, although the facet for its attachment is present. Nor is anything definitely known regarding the summit of the theca in case of any of the specimens here under investigation.

The central part of the figure accompanying the original description consists of one of the hexagonal plates belonging to the second series. The nodes at the four extreme corners have weathered away and exposed some of the structure of the interior, but there is no evidence of pores connecting with this interior. The four exterior ridges connecting the central umbonal part of this plate with the nodes at its four extremities are well shown, but the fifth ridge, extending directly downward to the basal angle of the thecal plate, is poorly indicated. From this basal angle, in a complete specimen, the ridge continues downward along the sutures between two of the basal plates, narrowing toward the base, but this part of the specimen is not preserved in the figured type, and the figure here is misleading. The group of horizontal ridges dominating the plates of the second series at mid-height is not adequately demarcated from the striæ above and below this horizontally ridged zone.

6. **Lycocystites nodosus** (Hall).

(Plate I, Figs. 11 A, B, C, D.)

Echinocystites nodosus Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 316, Pl. 12, Figs. 10, 11.)

Lysocystites nodosus Miller, N. Am. Geol. Pal., 1889, p. 259 (Echinocystites preoccupied).

Echinocystites nodosus was based on casts of the interior of the theca of a species described by Hall from the Racine dolomite at Racine, Wisconsin; later the generic name was changed to *Lysocystites*, *Echinocystites* being preoccupied. The type, numbered 2024, is preserved in the American Museum of Natural History in New York City. This type does not present clear evidence of the direction of the sutures between the plates, and therefore has been found of no service in unravelling the plate diagram of the species, nor in determining which is the top or bottom of the specimen. The clew to its structure was discovered by Arthur W. Slocom, who noticed that a specimen evidently identical specifically with *Lysocystites nodosus* formed the cast of the interior of a second specimen which was a cast of the exterior of a species having the same style of ornamentation as *Aethocystites sculptus* Miller, from the top of the Laurel limestone, at St. Paul, Indiana. Since the two specimens still were attached to each other, there was no possibility of error in the conclusion that they formed parts of the same specimen. With this clew as a guide it was found possible to orient several of the casts of *Lysocystites nodosus* belonging to Walker Museum at Chicago University. The best of these (Plate I, Figs. 11 A, B, C) is numbered 21815 and is from the type locality, Racine, Wisconsin. This has the following structure:

Casts of the interior of the theca.—At that end of the cast which corresponds to Figure 11 on Plate 12 accompanying Hall's original description of *Lysocystites nodosus*, three short narrow radiating ridges occur, and the outlines of three basal plates may be detected. Two of these plates are truncated above and the third is more rhomboid in outline and is angular at the top, as in the basal series of plates in *Aethocystites*. Along the upper margin of this basal series of plates are five more or less cuneate nodes, equidistant from each other, corresponding in position to the lower part of the sutures between the plates belonging to the second series. These cuneate nodes on the cast correspond in position to the lower series of strong angular nodes on the exterior of the theca. In addition to the five cuneate nodes there are three narrow vertical ridges, usually boldly defined, located at the upper end of the sutures between the three basal plates, and extending thence upward into the median part of those three plates of the second series which are angular at the base. All of these structures on the cast of the interior of *Lysocystites* correspond to salient features on the exterior of *Aethocystites*. Orientation of the specimen is facilitated by the fact that that one of the three short radiating ridges which is directed toward one of the nodes belonging to the lower series follows the median line of the narrow rhomboid basal plate. Passing from the node at the top of this plate two nodes toward the left, and thence vertically upward, the anal aperture will be found at the top of the third series of plates, slightly toward the right of this vertically directed line.

In Hall's Figure 11, the base of the theca has been interpreted as the summit. The specimen is so oriented as to place the rhomboid basal plate at the top of the figure. The narrow vertical ridge at the lower end of the figure was determined incorrectly as the ovarian aperture; no aperture of any kind being present here. The two other corresponding vertical ridges, at the upper end of the sutures on the right and left of the rhomboid plate are not clearly defined in the cast figured by Hall, and are not indicated in his figure. Figure 10 represents the type in an inverted position, with the supposed ovarian aperture occupying the middle of the upper part of the figure.

Returning to the Walker Museum specimen described above, a second series of cuneate nodes is located immediately above the first series, at the top of the second series of plates, but with the pointed end directed in the opposite direction. They locate the upper series of nodes visible on casts of the exterior of *Aethocystites*. The truncated ends of both the lower and upper series of cuneate nodes are separated more or less by a transverse groove from the rest of the nodes. If any pores connecting the plates are present they might be searched for here. The specimens at hand present no evidence on this subject. The upper or third series of plates can be diagrammed readily so as to conform to the system worked out for *Aethocystites sculptus*, although the suture lines are indicated only faintly.

After studying specimen number 21815, just described from the Walker Museum collections, other specimens of casts of the interior of *Lysocystites nodosus* become readily intelligible. In the Walker Museum

of Chicago University, for instance, there are five Racine specimens of *Lysocystites nodosus*, numbered 18943, all casts of the interior, in different states of preservation. Using the entire series, practically all the details already described in the case of specimen number 21815 can be made out. They differ from the latter chiefly in the appearance of the two series of nodes (Plate I, Fig. 11 D). These are not cuneate in outline and are not crossed at what corresponds to their truncated ends by a transverse groove. Moreover, these specimens are smaller in size than the one numbered 21815, but in all other features they so closely resemble the latter as evidently to be congeneric. Since there is no question of specimen number 21815 being congeneric with *Aethocystites*, the specimens numbered 18943 belong here also. The latter, however, are identical in character with the type of *Lysocystites nodosus*, so that the latter also evidently is congeneric with *Aethocystites*.

Exterior surface.—In the preceding lines it was mentioned that the cast of the interior of *Lysocystites nodosus* had been found by Arthur W. Slocom forming the interior of a specimen of *Aethocystites*. At the time of my visit to Chicago, this specimen was not accessible, but another specimen of *Aethocystites*, presenting the cast of the exterior, found in the Cedarville colomite at Wilmington, Ohio, forms number 2193 of the Walker Museum collection at Chicago University, and evidently has some bearing on the subject since the Cedarville dolomite carries a typical Racine fauna. This cast of the exterior shows the very characteristic surface markings of *Aethocystites*, including the nodes at the four angles of the plates of the second series. Only two plates of the second series are preserved, one of them truncated at the base, the other pointed. The original height of this Wilmington specimen is estimated at 19 mm.; the height of the Racine specimen numbered 21815, the first one described here, is about the same, but the specimen appears more rotund.

Locality and Horizon.—In the type area, *Lysocystites nodosus* is known definitely only from Racine, Wisconsin.

Remarks.—It is possible that there are two species of *Lysocystites* in the Racine dolomite of Wisconsin. In that case, the term *Lysocystites nodosus* must be restricted to forms like the type, in which the nodes at the four corners of the plates of the second series are not conspicuously cuneate in outline, and do not have their truncated ends similarly separated from the remainder of the nodes by transverse grooves. Specimen 21815 possibly belongs to a second species, and the cast of the exterior of *Aethocystites*, numbered 2193, from Wilmington, Ohio, may not belong to either of these species. For the present, however, all are regarded as belonging to a single species, the term *Lysocystites nodosus* covering all the forms here discussed.

USE OF TERM LYSOCYSTITES.—Since the generic name *Lysocystites* was proposed in 1889, five years earlier than *Aethocystites*, the latter is abandoned.

RELATIONSHIP.—*Lysocystites* was referred by Bather (The Echinoderma, 1900, p. 70) to the *Cryptocrinidæ*, the sole family of the *Aporita*. The relationship is even closer than hitherto suspected. In *Cryptocrinus*, from the Ordovician of Russia, there are three basal plates formed by the fusion of two pairs of the original five, the unfused plate being in the right anterior interradius. Alternating with the five original basal plates is a second series of five plates, all free from each other and hexagonal in outline, followed in turn, in alternating order, by a third series of five plates, subpentagonal in outline. The anus lies between two plates of the third series, separated from the nearest plate of the second series by a small supplementary plate. In all of these features *Cryptocrinus* closely resembles *Lysocystites*. The latter differs chiefly in the more elevated position of the anal aperture, the latter being located at the top of the third series of plates rather than between two of the latter. None of the plates of the fourth series, nor any of the tegminal plates at the extreme summit of the theca, are known in case of *Lysocystites*.

Holocystites Hall.

Holocystites Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 311, 380. Genotype: *Holocystites cylindricus* Hall.

Megacystites Hall, Addenda of preceding report, p. 380. Substitute for Holocystites.

Trematocystis Jaekel, Stammesgeschichte der Pelmatozoen, 1899, p. 414. Genotype: *Holocystites subglobosus* (Miller), Pl. 4, Fig. 2.

Holocystites of Hall.—The genus *Holocystites* was founded by Hall on six species of cystids which agreed in having the plates arranged in more or less alternating transverse or more or less alternating vertical rows, the plates of the more primitive species showing a marked tendency toward a predominance of hexagonal outlines. The oral aperture was terminal and the anal aperture was eccentric but only a short distance away from the oral one. The arms evidently were not recumbent and there was no trace of their former location.

The first three species described in the accompanying text agreed in being distinctly elongated in a vertical direction, the first species of this series being called *Holocystites cylindricus* on this account. In reality, three forms are figured under this name, of which figure 4 on plate 12 is regarded here as the type. The second described species, *Holocystites alternatus*, differs from the first by the intercalation of numerous supplementary plates between the transverse rows of more primitive plates.

The third species, *Holocystites abnormis*, differs from both the preceding in having the intercalated plates inserted in a more or less transverse row beneath the fourth series of plates, counting downward from the top of the theca. Of these three species, *Holocystites cylindricus* is regarded as the genotype.

The other three species, *Holocystites winchelli*, *H. ovatus*, and *H. scutellatus*, are oval or approximately spherical in form, and to these must be added *H. sphæricus* described by Winchell and Marcy from the Racine of the Chicago area, and *H. jolietensis* described by Miller from the Niagaran of Joliet, Illinois.

Holocystites of Miller.—The 40 so-called species of *Holocystites* described by Miller from the Osgood limestone of Indiana, one species being cited as though from the top of the Laurel limestone in the Waldron area, all agree in having the plates pierced by diplopores, the pores of each pair being connected just beneath the surface of the plates by peculiar channels frequently resembling the Greek letter Omega. Both the oral and the anal aperture have polygonal margins, the polygonal outline of the oral aperture being accentuated by the food-grooves leading from each angle of this aperture to the proximal end of a facet, each facet evidently serving originally for the support of a brachiole, since the food-groove indents the margin of each facet, although no brachioles ever have been found. At least 10 of these species had 5 brachioles, 2 more species probably having the same number. At least 16 species had 4 brachioles, 5 additional species probably having the same number of brachioles.

Holocystites amplus group.—Of the remaining 7 species described by Miller, 5 may belong to the group typified by *Holocystites amplus*. In this group, 3 food-grooves, narrowing distally, lead from angles of the oral aperture to large facets for the support of brachioles. The nearest relative to *Holocystites amplus* appears to be *Holocystites adipatus*, which preserves one of the long, rapidly attenuating food-grooves; *Holocystites tumidus* resembles *H. adipatus* in shape, and *H. ventricosus* may belong here also. *Holocystites gyrinus* agrees apparently in having three main food-grooves, but the latter do not attenuate strongly distally as in *H. amplus*, and both the left and left anterior food-grooves appear to bifurcate on reaching the facets, as though two arms were supported on a single protuberance in each case. The facet at the end of the right-hand ray is not preserved. Unfortunately, the upper end of the theca has been crushed from front to rear, producing the tantalizing conviction that some extremely interesting structure is here obscured. In the species with 3 main food-grooves, the length of these grooves is so much greater than in other species that there is a possibility of their belonging to a distinct genus. It is not certain, however, that *Holocystites gyrinus* belongs to the same group as *Holocystites amplus*, although the limitation of the food-groove system in both cases to 3 main strongly divergent rays suggests such a relationship.

Number of Arms.

The absence of arms on all known Osgood forms referred to *Holocystites* suggests that the latter were stiff and readily broken off, as in the case of the arms of the very different genus *Comarocystites*. The very distinct food-grooves are sufficient evidence of arms on the protuberances at their ends, especially in view of the fact that the food-grooves indent the margins of these protuberances.

There is no evidence of generic differences between species having 5 arms and those having 4 arms. Among species with 4 rays there are both smooth forms with the quadrangular margins surrounding the central oral aperture distinctly delimited, and coarsely papillate forms with the corresponding quadrangular margins rendered more indistinct by the presence of the papillæ. Moreover, there are variations in the length of the theca and in the arrangement of the plates which can not be brought into co-ordination with any oral structure.

ANAL APERTURE OF HOLOCYSTITES.

One distinct advance in our knowledge of the anal aperture has been made. This consists in the fact that the outline of the anal aperture in all cases is polygonal, usually either pentagonal or hexagonal, and covered with a pyramid consisting of as many triangular plates as there are sides to the aperture. Many of the specimens show the facets for the attachment of the plates forming the pyramid, but the pyramid itself has been observed in only one case, namely, in an undescribed species of *Holocystites*, of the elongate type, as in *H. alternatus*, which is numbered 10965 in Walker Museum of Chicago University, is labeled as coming from Jefferson County, Indiana, probably is from the Osgood formation, and retains distinctly 2 of the 5 plates belonging to its anal pyramid. These plates are triangular, almost equilateral in form, and are still in position. This specimen had 4 arms. A study of the material accessible at Chicago University led to the conclusion that no classification could be based on differences in the number of plates forming the anal pyramid. On the contrary, this number appeared to vary from 5 to 6 in the same species in several cases.

A study of the form of the theca and of the arrangement of the plates of the theca also failed to show any generic differences but led to other significant observations.

HOLOCYSTITES CYLINDRICUS GROUP.

For instance, there is a group of Osgood species, characterized by their elongate form and by the more or less definite arrangement of their plates, which closely resemble the group of elongate Racine species: *Holocystites cylindricus*, H. *alternatus* and *H. abnormis.* Corresponding to *H. cylindricus* is *H. canneus*, with 5 arms, although a few plates are irregularly inserted. Corresponding to *H. alternatus* are *H. bacculus* and *H. perlongus*, each with 5 arms. *H. plenus* with 5 arms probably also belongs here. Of the less elongate, more ovate species having supplementary plates inserted very much as in *H. alternatus* there are *H. splendens* with 5 arms, and *H. faberi*, *H. parvulus*, and *H. spangleri* with 4 arms. *H. abnormis* appears to be represented in its oblique form by *H. colletti*. After studying these more elongate Osgood forms it seems impossible to avoid the conclusion that we have here a series of species congeneric with the genotype of *Holocystites*. Unfortunately, the Racine species are known at present chiefly from casts of the interior of the theca, presenting little evidence of the structure of the exterior. The granulose surface of many of these Racine specimens is formed by the fillings of the pores traversing the thecal plates. While these pores appear to be arranged in pairs, no entirely conclusive evidence has been found. No trace of the Omega-like connections betwèen the pores has been noticed. The outlines of the oral and anal apertures are not preserved with sufficient distinctness in the specimens at hand. Finally, insurmountable obstacles result from the entire absence of any knowledge of the food-grooves and of the supports for the arms. This is due to the fact that collectors preserve only the casts of the interior of the theca but make no prolonged search for impressions of the exteriors. The latter usually occur only in large rocks, inconvenient to carry home, and in a fragmentary condition are not readily recognized as of value.

HOLOCYSTITES WYKOFFI GROUP.

In contrast to the elongate Osgood species of *Holocystites* is a group of globose forms, usually supported by a broad, flat base, the flattened area including several of the thecal plates. On one side of the specimen the plates have an elongate hexagonal form and are arranged in more or less transverse rows, while on the

opposite side of the same specimen this arrangement in rows may not be so evident. This arrangement is found in *H. wykoffi* and *H. sphæroidalis*, with 5 arms, to which *H. madisonensis* probably is closely related, with *H. subrotundatus* less certain. This tendency toward the arrangement of the plates in transverse rows is shown also by numerous ovate forms with coarsely papillate surfaces, having 4 arms, and including *H. affinis*, *H. benedicti*, *H. ornatissimus*, *H. papulosus*, and *H. subovatus*. Species of this type can not be differentiated generically from the smoother ovate forms, with 4 arms, in which there is no very obvious arrangement of the plates in transverse rows, as in *H. commodus*, *H. globosus*, *H. gorbyi*, *H. hammelli*, *H. indianensis*, *H. parvus*, *H. rotundatus*, *H. scitulus*, and *H. subglobosus*.

The studies here outlined have led to the conclusion that the importance attributed to the types of species has given rise to certain disadvantages as well as advantages. Although numerous specimens of *Holocystites* were collected formerly in the Osgood formation of southeastern Indiana, only the types were highly valued and have gone into the important collections. The other specimens became objects of trade and sale and have become practically lost to science. Hence, from the meager representatives of any one species it frequently is impossible to determine the range of variation in form, arrangement of plates, outline of oral or anal aperture, or the surface ornamentation. While the writer is convinced that the species described by Miller number only about one-fourth as many as indicated by the list of names, the material for more exact discrimination is lacking.

THE TERMS HOLOCYSTITES, MEGACYSTIS, AND TREMATOCYSTIS.

The generic name *Trematocystis*, proposed by Jaekel rests on the Osgood species *Holocystites subglobosus*. This is one of the smoother species with 4 arms, with a sharply angulate quadrangular border around the oral aperture, and with the plates more or less arranged in transverse rows, but not conspicuously elongated in a vertical direction along the lower of these rows. As far as may be judged from our present knowledge of the various Osgood forms, there is a considerable probability that this term eventually must be discarded for either *Holocystites* or *Megacystis*.

STUDIES BY BATHER.

In last year's numbers of the Geological magazine Bather has added greatly to our knowledge of the Osgood forms of *Holocystites.* In these numbers he has elaborated with his usual acumen our knowledge of this genus, and has accompanied the same with numerous drawings which illuminate every phase of its structure.

7. **Holocystites alternatus** Hall.

(Plate IV, Figs. 1, 2, 3, 4, 5, 6.)

Holocystites alternatus Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 312, Pl. 12, Fig. 9; Pl. 12a, Fig. 6.

Holocystites alternatus Foerste, Ohio Jour. Sci., 17, 1917, p. 233, Pl. II, Fig. 4.

In the type of *Holocystites alternatus* (Plate IV, Fig. 6) there are two sets of plates: a primary set, conspicuously larger in size, arranged in transverse rows with 8 plates in each row, and a distinctly smaller set inserted in transverse rows between the transverse rows of primary plates. Three of the rows of primary plates are lettered A, B and C; a fourth row, unlettered, occurs almost at the very base of the specimen. Between rows A and B, and between B and C, secondary plates were inserted at all points where three sutures met, resulting in octagonal outlines for the primary plates and pentagonal outlines for the secondary intercalated plates, the unpaired angle of the latter being directed alternately upward and downward. Between C and the lowest row of primary plates there was inserted first a secondary series arranged in transverse order, and above and below the latter a tertiary series was added, resulting in a very elongate theca.

A somewhat similar arrangement is noted in a specimen from the same locality, Racine, Wisconsin, numbered 839, and preserved in the Public Museum of Milwaukee (Plate IV, Fig. 1). The arrangement of the intercalated plates immediately below some of the plates of series C is very similar, but the interpretation of the lower plates requires the intercalation of three transverse rows of secondary plates, all at about the same time.

Three specimens are figured from the Cedarville dolomite at Cedarville, Ohio (Plate IV, Figs. 2, 3, 4). All of these are noteworthy for the simplicity of the plate system between rows C and D, there being only a single transverse series of secondary plates, with a few scattered, inconspicuous, tertiary ones.

In a specimen from Wilmington, Ohio, the intercalation of secondary and tertiary plates has been carried to an extreme, even the primary plates of row B being distinctly separated.

This Wilmington specimen is remarkable also for the excellent preservation of the lines of growth on the thecal plates. The most conspicuous evidence of growth along the margin of the larger plates is formed by a flattened border, from a millimeter to a millimeter and a half in width, above which the central part of each plate rises mod-

erately, but rather abruptly. From these zones it is evident that when some of the larger plates were smaller, some of the still smaller plates might have been absent altogether. In still earlier stages of growth only those plates here called primary probably were present. If this view be correct, then such species as *Holocystites cylindricus* and *Holocystites abnormis* might be regarded as retaining their primitive characteristics even in old age, and young specimens of species which in older age resemble *Holocystites alternatus* might be expected to resemble *Holocystites cylindricus* in their earlier stages of growth.

8. **Holocystites greenvillensis** Foerste.

Holocystites greenvillensis Foerste, Ohio Jour. Sci. 17, 1917, p. 203, Pl. 9, Figs. 3 A, B, C; Plate 10, Fig. 8.

This species, described from the Cedarville dolomite four and a half miles east of Greenville, Ohio, is an excellent example of a small form of *Holocystites* preserving its primitive characteristics, namely, about five transverse rows of plates, each row consisting of about 8 plates, the successive rows alternating with each other.

9. **Allocystites hammelli** Miller.

(Plate I, Figs. 13 A, B.)

Allocystites hammelli Miller, N. Amer. Geol. Pal., 1889, p. p. 222, Fig. 242.

Basal part, for a height of 5 mm., rapidly expanding from a width of 2.5 mm. to 6 mm.; bottom broken off; in place of a column there may have been merely an attachment area as in *Holocystites*. This basal part is followed by a circlet of 7 plates, the line of separation between two of these being indistinct. The next circlet contains 8 plates of larger size; in addition to this there are 3 pairs of accessory plates, vertically arranged, separating adjacent plates from each other, and to this is added another accessory area too poorly defined to be deciphered. The following or third circlet also consists of 8 plates of larger size; in addition there are accessory plates at 7 of the 8 intervening sutures; at 5 of these sutures the accessory plates are known definitely to be arranged in pairs, one plate directly over the other; at the other two sutures the same structure may exist but it is not decipherable. The following or fourth circlet also consists of 8 plates of larger size; in addition there appear to be pairs of accessory plates at 3 of the intervening sutures, and single accessory plates at the lower ends of apparently 4 of the remaining sutures. The anal aperture rests on the upper margin of two of these plates of the fourth circlet and is enclosed, laterally at least, by plates of the fifth circlet. The latter circlet consists of at least 7 plates, the two in contact with the anal aperture being of exceptional width, the remaining 5 being tall rather than wide. If there is a sixth circlet of plates, its presence can not be detected in the type specimen.

Surmounting the entire specimen, at least in its present condition, is a protuberance 2 mm. in height, constricted at the base, with a pentagonal outline at the top, with a width of 5.6 mm. between the right anterior and left anterior angles, and a diameter of 4 mm. from

the anterior angle to the posterior margin. From the five angles ridges extend toward the center of the rather flat top of the protuberance. These 5 ridges are not sharply defined and their actual structure remains obscure. There is no evidence of the presence of food-grooves. As far as may be determined from the single specimen at hand, the oral aperture may have been covered by a pyramid of 5 plates, somewhat as in *Sphæronis, globulus* Angelin, or as in *Glyptosphæra leuchtenbergi* Volborth, from the Ordovician of the Baltic areas of Russia.

Between the oral and the anal apertures there is a transverse ridge, interpreted as locating the madreporite. No gonopore can be detected.

The margin of the anal aperture protrudes slightly. Its outline is slightly elliptical, rather than circular, the diameters being 3 and 4 mm. The inner margin appears to be rhomboid with the major axis in a lateral direction, suggesting an anal pyramid of 4 plates, but the evidence is not clear.

Surface granulose, with the granules varying from slightly more to slightly less than a millimeter apart. Under a lens, very minute granules, not visible to the unaided eye, appear in great numbers. Where the surface of the plates has been removed in cleaning the top or fifth circlet of plates, there appear to be slight color changes suggesting the presence of the Omega-like ornamentation of the worn surfaces of the plates of *Holocystites*. Here, again, the evidence is not clear.

LOCALITY AND HORIZON.—From the Osgood formation on Riker's Ridge, about 4.5 miles northeast of Madison, Indiana. Type numbered 6006 in Walker Museum of Chicago University.

REMARKS.—Were it not for the oral protuberance, this specimen would be regarded readily as a typical species of *Holocystites*. It differs in plate system from such a form as *Holocystites greenvillensis* chiefly in the presence of numerous accessory plates. It is regarded as belonging to the same family. However, the anomalous oral protuberance is sufficient to establish it as a distinct genus.

10. **Gomphocystites indianensis** Miller.

(Plate I, Figs. 5 A, B.)

Gomphocystites indianensis Miller, N. Amer. Geol. Pal., 1889, p. 249, Fig. 319.

The upper, more globular part of the theca evidently has been compressed, but its outline, as seen from above, may have been distinctly elliptical even before compression. This is suggested by the relatively straight direction of the anterior and right anterior food-grooves along part of their paths, as seen in the figure accompanying the original description of the species. It is suggested also by the parallel direction of the straight parts of these food-grooves and by the angular curvature of the right anterior food-groove at mid-length. It will require additional specimens to determine how much of the elliptical form of the

theca is due to compression. The height of the globular part of the theca is about 20 mm. At the base it appears to have narrowed strongly to a short stipe, probably not over 15 mm. in length, although this part of the theca is not preserved.

The oral aperture is at the base of a deep, laterally elongated, triangular pit, the anterior food-groove departing from the anterior angle of this pit, the right anterior and right posterior food-grooves departing from the angle on its right, while the left anterior and left posterior food-grooves separate from each other at a point about a millimeter from the left angle of the pit. The most characteristic feature of the species consists in the relatively great width and depth of the food-grooves and their almost V-shaped cross-section. Along the proximal half of the length of the food-grooves their width equals about 1.5 mm. Along the sides of the food-grooves there are depressions or grooves which may locate the sutures between the bordering plates. If they represent branches of the food-grooves, then it should be observed that they lead to no facets for brachioles. Parts of the surface are so well preserved that the absence of any evidence of the presence of brachioles should be emphasized.

The food-grooves complete more than half of a circuit, the distal end reaching the lower side of the globular part of the theca. The distal end of theleft ant erior food groove curves upward toward the anterior food-groove and becomes parallel to the latter again for a short distance, as indicated in Fig. 5B on Plate I, and also in the figure accompanying Miller's description. The anal opening is circular and 3 mm. in diameter. No trace of the anal pyramid or of the small plates covering the food grooves remains.

The surface is strongly and irregularly granulose, most of the granules being about one millimeter, or a little less, distant from each other. Where the surface is worn, there are diplopores, the individuals of each pair being less than half a millimeter from each other. Where the surface is not worn, there is no trace of these diplopores.

LOCALITY AND HORIZON.—From the Osgood formation in Jefferson County, Indiana. Specimen numbered 6019 in the Walker Museum of Chicago University.

11. **Gomphocystites** sp.

(Plate III, 2 A, B.)

Theca depressed globular, narrowed strongly at the base to a short stipe probably a little over 5 mm. in length. Along part of the globular portion of the theca the sides appear flattened, but this may not be a constant feature. There is no tendency toward straightening of any part of any of the food-grooves as in the case of *Gomphocystites indianensis*. The distal ends of these food-grooves reach the lower part of the plattened sides of the theca. The distal end of the left anterior food-groove probably curves upward toward the anterior food-groove, as in *Gomphocystites indianensis*. Along part of the anterior food-groove, several

short grooves branch off from the main food-groove and terminate abruptly near the middle of thecal plates, but without any evidence of facets for the support of brachioles. Compared with *Gomphocystites indianensis*, the surface is papillose rather than granulose, the papillæ being about 1.5 mm. or more distant from each other. The width of the food-grooves is about a millimeter or slightly less, and their cross-section is shallow U-shaped, rather than deeply V-shaped.

Locality and Horizon.—From the base of the Louisville limestone, immediately over the Waldron shale, at the railroad cut two miles east of Anchorage, Kentucky.

Remarks.—While this Louisville specimen is regarded as belonging to a new species, the state of preservation of the specimen figured makes the latter undesirable as a type.

12. **Gomphocystites bownockeri** Sp. nov.

(Plate III, Figs. 1 A, B; Plate I, Figs. 6 A, B; 9 A, B; Plate II, Figs. 9 A, B.)

Ohio specimens.—Thecas obliquely compressed, originally probably depressed globose, rapidly narrowed at the base to a short stipe, probably not over 10 or 15 mm. in length. Oral aperture elongated transversely, about 4 mm. wide and 3 mm. long from front to rear along its median line. Thecal plates varying in size; those along the outer margin of the food-grooves tending to be smaller, more or less elongated at right angles to the food-grooves, the intermediate sutures having the same direction, the resulting appearance being that of oblong bodies packed together laterally. Usually only that row of plates which is in immediate contact with the food-groove presents the laterally compressed appearance in a striking manner, but a second row frequently offers a similar appearance along a part of its length and in a less obvious manner. In the spaces between those rows of plates which are adjacent to the food-grooves there are other plates varying considerably in size and some of these plates are much larger than any forming the rows. Larger plates occur also along the lower part of the theca, including the stipe.

The anal aperture is 4 mm. in diameter, and 3 mm. distant from the nearest part of the oral aperture. The food-grooves extend at least below mid-height of the globular part of the theca, and probably reach its lower part. The food-grooves are faintly impressed on the type specimen, the latter being regarded as a cast of the interior of the theca.

The plates show marginal depressed areas, with central raised parts, interpreted as evidences of marginal growth. The marginal depressed bands of the larger plates are about 1 mm. in width, and those of the smaller plates are narrower, suggesting the later intercalation of the smaller plates.

Locality and Horizon.—From the Cedarville dolomite at Cedarville, Ohio. Type, numbered 8736A, in the Museum at Ohio State University. A second specimen, 8736B, 40 mm. in width, shows similar features.

Racine specimens.—*Gomphocystites bownockeri* occurs also in the Racine dolomite of the Chicago area. Several specimens, numbered 22944, are preserved at Chicago Univesrity. The one marked 22944A shows the row of laterally compressed plates, along the lower side of one of the food-grooves, very well. The thickness of the thecal plates is almost 2 mm. The middle layers of most of the plates have weathered away, leaving the fillings of some of the diplopores exposed in the form of columns. The exterior layers of a sufficient number of these plates has been preserved to indicate that the food-grooves are relatively narrow, only a millimeter or less in width, but rather sharply impressed; on casts of the interior of the theca they are only faintly indicated. At one point, several short lateral branches of the food-grooves seem to be present.

In a specimen numbered 4523 at the U. S. National Museum, short lateral grooves branch off diagonally from the lower side of the main food-grooves and terminate at small facets, evidently for the support of brachioles. The combined length of the branches with the terminal facets is 2 mm. Along the proximal part of the main food-grooves 5 facets occur in a length of 10 mm. No clearly defined lateral grooves and facets were noticed along the upper side of these main food-grooves.

Surface ornamentation.—Two specimens of *Gomphocystites* from the Chicago area, numbered 22943 at Chicago University, present impressions of parts of the exterior surface. One of these consists of the impression of the top of a specimen, and shows food-grooves, a relatively coarsely papillate surface, and numerous diplopores, the pores of each pair averaging about half a millimeter or less apart. The second specimen retains the impression of the attenuate basal stipe, 15 mm. long, and also the impression of part of the lateral wall of the globose part of the theca. The tips of the food-grooves evidently reach the lower slopes of the globose part of the theca. The striking feature of this specimen is its strongly papillate ornamentation, the papillæ on the upper surface of the theca frequently being 1.5 to 2 mm. apart, while those on the stipe may be one millimeter or even less distant from each other.

Food-groove system.—The food-grooves are deeply incised into the outer surface of the theca. Three primary branches leave the oral aperture. Of these, the anterior branch remains undivided; the right branch divides slightly over one millimeter from the center of the oral aperture; the left branch divides at a distance of about 2 mm., the resulting total being 5 branches. The width of the food-grooves is one millimeter or less.

Variation in the form of the theca.—Two of the specimens from the Chicago area, numbered 22944 at Chicago University, namely B and C, are nearly globular rather than depressed globular in form, but present the same rows of laterally compressed small plates along the lower side of the food-grooves as in *Gomphocystites bownockeri*. Specimen 22945 (Plate I, Figs. 9 A, B) from the same area, differs merely in its more elongate form. In all of these specimens the tips of the food-grooves extend practically to the base of the more globular part of the theca.

One of the specimens found at Cedarville, Ohio (Plate II, Figs. 9 A, B) also presents a globose form, but the food-grooves apparently extend only half way down the globose part of the theca. It consists of a rather poorly preserved cast of the interior of the theca.

REMARKS.—Hall described only two species of *Gomphocystites* from the Racine dolomite, *Gomphocystites glans* and *G. clavus*, both from Racine, Wisconsin. The type of the genus is *Gomphocystites tenax*, from Lockport, New York. All of these species described by Hall have long stipes, while all described in the present paper have short stipes.

Narrawayella Gen. nov.

Cyclocystoides.—The genus *Cyclocystoides* was based by Billings and Salter (Geol. Surv. Canada, Dec. 3, 1858, p. 86) on *Cyclocystoides halli* Billings. The conspicuous part of this species, as far as known, consists of a ring of relatively large plates, surrounded by a peripheral margin of small imbricating plates. The proximal half of the large plates is strongly elevated above the distal half; it is evenly convex, and covered with low granules. The distal half of each plate usually shows two spoon-shaped depressions. The outer edge of the proximal half of the large plates is under-cut, and this under-cutting extends backward into proximal half of the plate as a funnel-shaped pit, but it is not definitely known whether this pit continues in the form of a pore entirely through the plate.

In American strata, 6 species having this type of structure are known. These are: *Cyclocystoides anteceptus* Hall, from the Black River of the Escanaba River; *Cyclocystoides halli* Billings, from the Curdsville member of the Trenton in Canada; *Cyclocystoides salteri* Hall, from the Trenton near Saratoga Springs, New York; *Cyclostoides bellulus* Miller and Dyer, from the Fairmount at Cincinnati, Ohio; *Cyclocystoides magnus* Miller and Dyer, from the Fairmount at Morrow, Ohio; and *Cyclocystoides huronensis* Billings, from the Richmond on Rabbit Island, in Lake Huron.

None of the other seven described American species referred to this genus are known to have the structure found in *Cyclocystoides halli*. There is no evidence for regarding them as true species of *Cyclocystoides*. In fact, they differ not only from that genus but also among each other.

Narrawayella.—One of these distinct groups is typified by *Cyclocystoides cincinnatiensis* Miller and Faber, from the Corry-

ville member of the Maysville formation at Cincinnati, Ohio. In this species the plates are coarsely pitted. *Cyclocystoides nitidus* Faber, from the Corryville member, near Transit, Ohio, also is coarsely pitted and may be the same species, differing only in having 24 instead of 30 plates in the ring of large plates. *Cyclocystoides mundulus* Miller and Dyer, probably from the Corryville at Morrow, Ohio, with 32 plates, probably belongs to the same group. Raymond describes and figures a similar specimen of the same type (Bull. Victoria Memorial Museum, 1, 1913, p. 28, Fig. 3, Pl. 3, Fig. 4) from the *Prasopora* zone of the Trenton in the Axe Factory quarry, at Hull, Quebec. This specimen is in the Narraway collection and is described as having the large plates covered with small pits between which are rounded inosculating ridges. For this group of pitted species, typified by *Cyclocystoides cincinnatiensis*, the term *Narrawayella* is proposed, in recognition of the great service to paleontology rendered by Mr. J. E. Narraway during his life as a collector of fossils in the rich area surrounding Ottawa, in Canada. For the species described and figured by Raymond, the name *Narrawayella raymondi* is offered. In this group of species the outline of the large plates is cuneate rather than quadrangular, and there is no evidence of spoon-shaped ornamentation on the distal halves of the plates.

Cyclocystoides minus Miller and Dyer and *Cyclocystoides parvus* Miller and Dyer, both from Morrow, Ohio, the first with 19 plates, the second with 26 plates in the main ring, are not sufficiently understood but may belong to the same group as the preceding. I do not know on what authority these species are cited from the Richmond.

Agelacrinus arm.—A remarkable specimen figured by Miller and Faber (Jour. Cincinnati Soc. Nat. Hist., 15, 1892, p. 85, Pl. 1, Figs. 13–15), from the hilltop at Cincinnati, Ohio, as probably a fragment of *Cyclocystoides magnus*, consists of a fragment of either *Agelacrinus cincinnatiensis* or *Agelacrinus pileus*, exposing both the upper and lower surface of one of the rays, and some of the adjacent plates. The floor plates of this ray overlap each other distally, and along the margins of the floor-plates are seen the basal extensions of the lateral covering plates, as in ray 3 of Figure 5A, Plate 1, accompanying my paper on *Agelacrinidæ*, in the Bull. Denison Univ., 17, 1914, pp. 399–487. See also volume 18, 1916, pp. 340, 341.

Savagella Gen. nov.

Recently Savage described a remarkable form from the Orchard Creek shale, near Thebes, Illinois, under the name *Cyclocystoides ornatus*. The large plates forming the conspicuous ring are similar to those of typical *Cyclocystoides* in being quadrangular in shape, but here the similarity ends. Along their upper surface the plates are radially grooved, their inner face is vertical, and their lower surface is convex, their radial cross-section being subtriangular. There is no structure comparable with the spoon-like ornamentation of typical *Cyclocystoides*, moreover the steep inner face of the ring-plates must have been correlated with an altogether different structure of the theca interior to the ring. Therefore the new generic term *Savagella* is proposed, with this species as the genotype.

Cyclocystoides illinoisensis.—A fourth generic type is represented by *Cyclocystoides illinoisensis* Miller and Gurley, from the same locality and horizon as *Cyclocystoides ornatus*. The ring plates of this species are flattened, without conspicuous ornamentation, and their radial cross-section has a flattened elliptical form. For this fourth generic type no new name is provided at the present time although it is believed that it will prove distinct when better understood.

These four genera—*Cyclocystoides*, *Narrawayella*, *Savagella*, and the unnamed genus having *Cyclocystoides illinoisensis* as a type—are included in the family *Cyclocystoididæ*, proposed by S. A. Miller (Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 223), with *Cyclocystoides* as the typical genus around which the others are grouped.

In proposing these new names it is fully realized that the structure of these peculiar organisms is not fully understood. It is believed, however, that the first step to their understanding is to note that the species hitherto grouped under the single term *Cyclocystoides* differ greatly in structure and probably represent several distinct but closely related genera.

13. Savagella ornatus Savage.

(Plate 1, Fig. 18.)

Cyclocystoides ornatus Savage, Trans. Illinois Acad. Sci. 10, 1917, p. 265, Pl. 2, Fig. 1.

Type: Disk 18 by 20 mm. in diameter. Submarginal ring, consisting of 20 plates. The individual plates are about 1 mm. long in a radial

direction, and 2.5 mm. wide in a direction parallel to the circumference of the theca. Their radial cross-section is subtriangular. Along their inner faces they are abruptly vertical. Their upper faces curve downward with even convexity as far as mid-height on the outer margin of the plates; these upper faces are crossed radially by low ribs, usually five, sometimes four, on each plate. The lower faces also are moderately convex. The narrow intervals between the plates are occupied by a darker substance which, originally, may have been flexible, permitting the submarginal ring to be flexible.

The submarginal ring of plates is bordered exteriorly by a marginal band of imbricating plates. Those in contact with the ring usually equal or slightly exceed 1 mm. in width, sometimes attaining a width of 1.5 mm.; they appear to be short but wide, with broadly convex free margins. The other plates are successively narrower, those at the margin of the theca usually being about half, or slightly more than half, of a millimeter in width; they are longer than wide.

The basal part of the specimen, within the submarginal ring, appears to be formed by numerous plates from less than one millimeter to slightly over one and a half millimeters in diameter. These are irregularly convex, so as to produce moderate depressions at numerous points. Their margins are too poorly defined to determine whether there is any definite system in their arrangement.

Locality and Horizon.—From the Orchard Creek shale, near Thebes, Illinois.

Specimen figured and described by Miller and Gurley as one of their types of *Cyclocystoides illinoisensis* (Fig. 28 on Plate 5, Bull. Illinois State Mus. Nat. Hist., 1895; also Plate I, Fig. 18 of the present paper). This specimen was described as having 13 submarginal plates, forming not much, if any, more than one-half of a circle. From this the inference is drawn that the complete specimen had 24 to 30 plates. As a matter of fact fourteen plates and half of a fifteenth are present, there are sufficiently distinct impressions to indicate the former presence of three additional plates, and their total number could not have exceeded 20, although apparently there is room only for 18 or 19. The radial cross-section of the plates is subtriangular, with the inner face abruptly vertical as in *Cyclocystoides ornatus*. The radially directed ribs on the upper faces of the latter are absent, but this upper surface is so badly worn in the Miller and Gurley specimen, here described, that the failure of these ribs to appear has no diagnostic value. There are four or five series of small plates in the marginal band surrounding the submarginal ring. In the opinion of the present writer, this specimen, the second one of those figured and described by Miller and Gurley, should be referred to *Cyclocystoides ornatus* Savage, and the name *Cyclocystoides illinoisensis* should be restricted to forms resembling Figure 27 accompanying their original description.

Miller and Gurley describe the plates of the marginal band as elongated nodes.

REMARKS.—The characteristic features of *Cyclocystoides ornatus* are the subtriangular radial cross section of the submarginal plates, with the inner face abruptly vertical, and the upper face crossed radially by 4 to 5 low ribs; the individual plates are much wider tangentially than long radially, and usually are distinctly separated from each other laterally, often from half to three-quarters of a millimeter.

14. **Cyclocystoides** (?) **illinoisensis** Miller and Gurley.

(Plate I, Figs. 17 A, B.)

Cyclocystoides illinoisensis Miller and Gurley, Bull. Illinois State Mus. Nat. Hist., 6, 1895, p. 61, Pl. 5, Fig. 27.

The species *Cyclocystoides illinoisensis* was founded on two fragments of the submarginal ring, found in the Orchard Creek shale, on Orchard Creek, near Thebes, in Alexander County, Illinois. These specimens differ in character. In the specimen described first, forming Figure 27 on Plate 5 accompanying the original description, (Plate I, Fig. 17A of present paper), 9 plates of the submarginal ring are present. These are nearly square in outline, neither the tangential nor the radial diameter differing far from 2 mm. The exposed surface is much flattened in a direction parallel to the disk, and the radial cross-section is very depressed elliptical, with a vertical diameter of 1 mm. The plates are in close contact laterally. Exterior to the submarginal ring are numerous small marginal plates arranged in short diagonal rows of 3 or 4 plates. Of these, those nearest the submarginal ring are nearly 1.5 mm. in width, while those nearest the free margin are much smaller.

In their description of this specimen, Miller and Gurley state that the nine large plates present appear not to form more than a third of a circle. In my own opinion, however, they form nearly half of the submarginal ring, the latter being somewhat elliptical in form. At least in a more complete specimen, (Plate I, Fig. 17 B) collected at the same locality, in the same shale, and preserved in the Museum of Illinois State University, exactly 20 plates are indicated either by plates actually present or by the impression left by those that are missing.

LOCALITY AND HORIZON.—From the Orchard Creek shale, on Orchard Creek, near Thebes, in Alexander County, Illinois. The type, numbered 6051A, is preserved in the Walker Museum, at Chicago University. The specimen here figured belongs to the Museum of the University of Illinois.

REMARKS.—The second specimen figured and described by Miller and Gurley under *Cyclocystoides illinoisensis* is regarded as belonging to *Cyclocystoides ornatus*, Savage, described from the same locality and horizon.

15. **Troostocrinus sanctipaulensis** Sp. nov.

(Plate I, Fig. 16.)

Closely similar to *Troostocrinus reinwardti* (Troost), from the Beech River division of the Brownsport limestone of Western Tennessee. Most of the differences are slight. The sinus in the upper part of the radials tends to be more narrow; the median part of the lower half of the radials, beneath the sinus, tends to be more angular, the intermediate part, along the sutures, being more or less concave; and the lower end of the radial sinus is slightly lower, being in direct contact with the most extended part of the median fold immediately beneath. Cross-sections of the theca agree in being pentagonal along the lower half of the radials and triangular along the basals, the angles occupying the median parts of each of the three basals. In the specimen figured, the basal part of the theca appears less attenuate but another specimen from the same locality shows greater attenuation. The most conspicuous differences are to be noted in the ambulacra. While the number of side-plates in the same length appears to be about the same, namely 16 in a length of 5 mm., the individual side plates appear to be more convex, the median line separating the side-plates is much more conspicuously grooved, and this groove zig-zags less from side to side.

Locality and Horizon.—From the top of the Laurel limestone at St. Paul, Indiana. Four specimens numbered 22909, preserved in Walker Museum at Chicago University; only one is figured; another presents the details of the oral end of the theca.

Remarks.—Whether the differences noted above are sufficient to warrant the erection of a new species is an open question. Additional specimens are necessary to determine how constant the differences noted are. Students of the crinoidea are aware of the frequency with which species occurring at St. Paul find their nearest relatives in the Waldron, Brownsport, and Racine, many of them showing Gotlandian affinities. From this point of view, the occurrence of the blastoid *Troostocrinus*, hitherto known only from higher strata, in the upper part of the Laurel formation at St. Paul is entirely normal.

16. **Troostocrinus reinwardti-minimus** Var. nov.

(Plate I, Fig. 14.)

Closely related to *Troostocrinus reinwardti*, from the middle or *Troostocrinus* zone of the Beech river division of the Brownsport formation in western Tennessee. It differs in being much smaller, and more slender; compared with the total length of the radials, the triangular parts between the radial sinuses are relatively shorter; moreover, the

tips of these triangular parts tend to be less convergent. Along the sutures between the radials the theca is sufficiently concave to give a distinctly pentagonal cross-section to the upper half of the theca, while the basal part has a triangular cross-section, as is usual in this genus.

LOCALITY AND HORIZON.—From the Bainbridge phase of the Niagaran, six miles west of St. Marys, in St. Genevieve County, Missouri. Collected by Doctor Herrick E. Wilson, and numbered 14791 in the collections of Walker Museum at Chicago University.

REMARKS.—The following new species have been described from the Niagaran locality at St. Marys, all by Prof. R. R. Rowley: *Cordylocrinus ? dubius*, *Cyathocrinus ovalis*, *Lecanocrinus hemisphericus*, *Pisocrinus glabellus*, *Pisocrinus granulosus*, *Scenidium ? nodocostatum*, and *Stribalocystites missouriensis*. In addition to these, Prof. Rowley identified two species as *Pisocrinus globosus* Ringueberg and *Pisocrinus gorbyi* Miller. The fauna is regarded as equivalent to some part of the Brownsport formation of western Tennessee.

Troostocrinus ? dubius and *Melocrinus wittenbergensis* were described by Rowley from a Helderbergian locality near Wittenberg, Missouri. The *Troostocrinus* should be re-examined to verify its generic reference.

Of the species listed, *Scenidium nodocostatum* belongs to the same group as the species described originally by Hall and Whitfield, from the Louisville limestone of Kentucky, as *Orthis nisis*. This is not a *Scenidium*.

17. **Troostocrinus subcylindricus** (Hall and Whitfield).

(Plate III, Figs. 3 A, B, C.)

Pentremites subcylindrica Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 1875, p. 129, Pl. 6, Fig. 13.

As in all other *Eublastoidea*, 5 fork-shaped radials are supported by 3 basals. The bases of the right posterior and left anterior radials rest on the truncated tops of two of the basals, the top of the third basal, occupying the right anterior interradius, being acutely angular. Theoretically, each of the two truncated basals was formed by the lateral coalescence of two basals. Only the posterior deltoid can be detected readily, the other four being restricted to the extreme tip of the acute interradial areas. The anal aperture opens through the oral extremity of the posterior deltoid.

In *Troostocrinus subcylindricus*, the surface of the radials rises on approaching the radial sinuses, the rise increasing toward the lower end of the sinuses. Immediately beneath the lower end of the sinuses the

median part of each radial curves conspicuous outward for a distance of about one millimeter. Near mid-height of the radials the cross-section of the theca is pentagonal but along the basals this cross-section changes to triangular, as in other species of *Troostocrinus*.

In the type (Plate III, Fig. 3A), the distance between the base of the radials and the lower end of the ambulacra is 17 mm., and from the latter to the acute tip of the areas between the sinuses the distance is about 11 mm. The lateral diameter of the theca just beneath the projecting lower ends of the sinuses is 15 mm. The basals diverge rather strongly, as in figure 3B on Plate III. The divergence of the lower part of the radials is much less, giving rise to the specific name *subcylindrica*. In another specimen (Plate III, Fig. 3C), recently found at Cedarville, Ohio, the theca is much more elongate.

LOCALITY AND HORIZON.—From the Cedarville dolomite. The type, numbered 3306, accompanied by the basal part of another specimen, is in the Museum of Ohio State University; both specimens were obtained at Yellow Springs, Ohio. A third specimen, here figured, was obtained in the quarry at Cedarville, Ohio.

REMARKS.—*Troostocrinus subcylindricus* is characterized by the strong outward curvature of the median part of the radials immediately beneath the lower end of the radial sinuses. This is shown conspicuously on lateral view.

In *Troostocrinus reinwardti*, from the Brownsport formation of Western Tennessee, there is no corresponding outward curvature of the median part of the radials. On the contrary, on lateral view the median parts of the radials curve slightly inward rather than conspicuously outward just before reaching the lower end of the radial sinuses. The length of this convex curvature is only about one millimeter. Moreover, the lower third of the theca usually is much more slender, the lower half of the radials diverging more strongly. In the Brownsport species, the side-plates number about 16 in a length of 5 mm. The surface of the ambulacra, compared with that of other species, is distinctly flattened, the groove between the series of side-plates being not consicuous, nor straight, but zigzaging rather strongly between the alternating side-plates.

18. **Troostocrinus** sp.

(Plate I, Fig. 15.)

Only a single specimen of *Troostocrinus* is known from the Chicago area. This specimen is numbered 22907 in Walker Museum at Chicago University, and is from Bridegport, Illinois. It evidently is from the

Racine horizon. Considering the close resemblance between the Racine faunas of Illinois and Wisconsin and the Cedarville fauna of Ohio, this Bridgeport specimen might be expected to show close affinity to *Troostocrinus subcylindricus* (Hall and Whitfield), from the Cedarville dolomite. Compared with the latter it presents the following differences:

The radial sinuses are more narrow, varying from 1 mm. to slightly over 1.5 mm. in width. The triangular areas between these sinuses are relatively shorter, have a somewhat wider apical angle, are only slightly concave, and are more strongly and more abruptly inflected toward one another. Near the lower end of the radial sinuses the cross-section of the theca is pentagonal, the lower half of the radials being angular along the median line, but their curvature along this line is not outward on approaching the lower end of the sinuses, as in *Troostocrinus subcylindricus.* All parts of the theca are relatively shorter than in the latter species, the result being a blunter top, and a more rapidly attenuating base to the theca.

Compared with *Troostocrinus sanctipaulensis*, the theca is similar to the figured specimen, in the shorter form and resultant outline, in the narrowness of the radial sinuses, and in the absence of any outward curvature of the median part of the radials just beneath the lower end of the radial sinuses. It differs in the triangular areas between these sinuses being shorter and less abruptly curved inward.

Additional specimens will be needed to discriminate this form if it be distinct from those already described.

19. **Crinocystites chrysalis** Hall.

(Plate I, Figs. 2 A, B; 3 A, B.)

Crinocystites chrysalis Hall, 20th Rep. New York State Cab. Nat. Hist., 1868, p. 318, Pl. 12a, Figs. 10, 11.

The type of *Crinocystites chrysalis* (Plate I, Figs. 2 A, B), from the Racine dolomite at Racine, Wisconsin, is preserved in the American Museum of Natural History, in New York City. As figured by Hall, this type consists of a clavate, moderately curved body; the sutures between the plates are represented correctly, but there are no arm supports, the specimen having been incorrectly interpreted in this respect. Both of the figures presented by Hall are inverted from their natural position.

Arthur W. Slocom, the curator of the Walker Museum at Chicago University, called my attention to the fact that *Crinocystites chrysalis* was merely the cast of the interior of some other body whose exterior aspect was very different. This was shown by specimen 22914 in Walker Museum, which came from the same horizon and locality as the type of *Crinocystites chrysalis.* Prof. Stuart Weller at once recognized the similarity of this specimen to *Eucalyptocrinus proboscidialis* Miller (Plate I, Fig. 4) from the Cedarville dolomite, at Pontiac, Ohio (Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2). Formerly Pontiac was the seat of a lime industry. It was a railroad station, five miles south of Sidney, in Shelby County. Here the Racine phase of the Cedarville dolomite is exposed.

A comparative study of the type of *Crinocystites chrysalis*, of the Chicago University specimen of that species, and of *Eucalyptocrinus proboscidialis* demonstrates that *Crinocystites chrysalis* is a cast of the interior of the anal tube of a species of *Eucalyptocrinus*, using that term in the broad sense in which it is applied at present. The following is a description of the Chicago University specimen.

Chicago University specimen.—The specimen retains distinct impressions of the exterior surface of the upper part of the 10 wing-like processes that surround the tegmen, and that serve as partitions between the vertical compartments sheltering the arms. No trace of these arms remains. The upper edge of these processes projects horizontally outward, their total extension across the entire width of the specimen being 18 mm., while 7 mm. farther down the attenuated upper part of the tegmen has a width of only 5 or 6 mm. The upper surface of the wing-like processes forms a platform, above which rises a further extension of the tegmen in the form of an anal tube. At its base this anal tube has a width of 7.5 mm., decreasing to about 3.5 mm. in a length of 14 mm., above which it is not preserved. The plates forming the anal tube are elevated towards their centers in a strongly nodose manner. They are arranged in about ten vertical series, the lower plate of each series being directly above the top of one of the wing-like processes already described. Four or five plates occur in each vertical series, as far as preserved, the plates in adjoining rows alternating with each other. Counted in a transverse direction, the plates at the base are arranged in circles of five plates each, the plates of successive circles alternating. It is not known whether the number of plates in a circle continues to be five as far as the top of the anal tube.

The cast of the interior of the anal tube is continued downward into the cast of the interior of that part of the tegmen which is included between the top of the wing-like processes. The upper part of this cast of the interior, for a length of 14 mm., retains traces of the plates forming the anal tube; the lower part, 6 mm. in length, shows a vertically elongated flattened area beneath each of the vertical rows of the anal tube, somewhat as in *Eucalyptocrinus proboscidialis.* In the latter, however, that part of the tegmen which is included between the upper part of the wing-like processes is constricted strongly beneath while in *Crinocystites chrysalis* the corresponding part is constricted only sufficiently to give the entire cast included under that name by Hall an inverted clavate appearance, with the maximum expansion on a level with the top of the wing-like processes.

The Chicago University specimen agrees with the type of *Crinocystites chrysalis* in having the anal tube moderately curved lengthwise. That part of the cast of the exterior of the anal tube of the Chicago University specimen which is best preserved belongs to the concavely curved side of this tube, but the amount of this curvature is slight. That part of the cast of the interior of the anal tube which is best preserved belongs to convexly curved side of the tube. This curvature is more distinct, and this is the side of the tube here figured.

Locality and Horizon.—From the Racine dolomite at Racine, Wisconsin. The Chicago University specimen is numbered 22914, and consists of the two parts described in the preceding lines. The type of the species, numbered 2023, is preserved in the American Museum of Natural History, and consists of the cast of the interior of the anal tube and of the top of the constricted part of the tegmen.

Remarks.—While it is very probable that the Chicago University specimen here described belongs to the same species as the type of *Crinocystites chrysalis*, this is not absolutely certain. The anal tube of the latter is more curved lengthwise, is wider at the base, is more strongly clavate, and has a different arrangement of plates toward the top of the anal tube.

Eucalyptocrinus proboscidialis Miller (Plate I, Fig. 4 of present paper), is a closely related species.

The form most closely resembling *Eucalyptocrinus proboscidialis* is *Eucalyptocrinus egani* Miller (Jour. Cincinnati Soc. Nat. Hist., 3, 1880, Pl. 4, Figs. 1-1c), from the Racine dolomite at the Bridgeport locality, in Chicago, Illinois. From the figures accompanying the original description of this species it is evident that an anal tube extended above the platform formed by wing-like processes, but only the five lower plates of this tube are indicated on the cast of its interior, and it is not known definitely how much longer the anal tube was. The original specimen used for figure 1 c, accompanying the original description of this species, is in the museum of the Cincinnati Society of Natural History.

An anal tube rising above the platform of wing-like processes occurs also in a specimen from Racine, Wisconsin, which closely resembles *Eucalyptocrinus nodulosus* Weller, a cast of which is preserved in the Springer collection in the U. S. National Museum.

All of these species with anal tubes projecting above the platform of wing-like processes differ from *Eucalyptocrinus rosaceus* (Goldfuss), the type of the genus, from the Devonian of the Eifel, the anal opening of the latter consisting of a small aperture between four plates at the center of the platform.

Among European Calyptocrinids, the American species here discussed resemble most the form originally described by Phillips as *Hypanthocrinites decorus.* The latter also has an anal tube distinctly rising above the platform of wing-like processes.

In most American species of *Eucalyptocrinus*, the anal opening is among a series of small plates forming the central part of the flat platform of wing-like processes. Only in *Eucalyptocrinus lindahli* Wachsmuth and Springer do the wing-like processes extend strongly outward horizontally as in *Eucalyptocrinus rosaceus*, the genotype.

At present there is no disposition on the part of specialists to subdivide the genus *Eucalyptocrinus*, so that *Crinocystites chrysalis* may be regarded provisionally as the anal tube of some species of *Eucalyptocrinus*. Eventually, however, it may be found desirable to segregate those species in which the anal tube rises conspicuously above the platform of wing-like processes. In that case it may be necessary to determine whether the American species here discussed are as closely related to *Hypanthocrinites decorus* as the general appearance of the latter suggests.

Eucalyptocrinus proboscidialis Miller.

(Figure 4.)

Eucalyptocrinus proboscidialis Miller, Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2.

Calyx obconical, rising from a small, flattened base, consisting of the basals alone. Radials almost as tall as wide; first costals fully as tall as wide; second costals with equilateral pentagonal outlines. First distichals about equal in size to the second costals, those of the same ray in contact with each other laterally, so that the interdistichal does not truncate the second costal but has an angular basal margin. Second distichals much smaller; the palmars which support the arms are not differentiated clearly; the interdistichal is narrower but slightly longer than the second distichals. The lower interbrachial is almost twice as tall as wide; it is surmounted by a pair of interbrachials the upper parts of which project distinctly above the general margin of the calyx. The width of the calyx at its upper margin is about four-fifths of its vertical height.

The lower part of the tegmen, for a vertical height of 5 mm., is only slightly narrower than the top of the calyx; above this point it contracts, at first rapidly and then more gradually, reaching its narrowest dimensions about 24 mm. above the top of the calyx. Farther up it widens again, at first gradually and then more rapidly, to a level 37 mm. above the top of the calyx, somewhat as in a very much elongated hour-glass. To this height extend the compartments sheltering the arms. Above this extends an anal tube about 53 mm. in length.

The lower part of the tegmen, for a vertical height of 11 mm., consists of a circlet of 10 oblong plates separated toward the base by a series of smaller plates, also 10 in number. Each of the 10 larger oblong

plates supports one of the vertical radiating wing-like partitions separating the compartments sheltering the arms. Alternating with the tops of the larger oblong plates is another series of plates, narrowing rapidly upward and forming the lower third of the narrowly contracted part of the tegmen. At its narrowest part, the diameter of this contracted portion of the tegmen is scarcely 3 mm.; the individual plates of this portion can not be differentiated in the type specimen. The upper third of the much elongated "hour-glass" portion of the tegmen consists of plates narrowing rapidly downward and producing a structure similar to an elongate funnel. The number of plates forming the circlet here can not be determined; it seems to be 8 but may be 10. The top of the funnel like portion of the tegmen widens into a narrow platform, apparently 18 mm. in width, forming the top of the compartments sheltering the arms. About halfway between the top of the calyx and the platform at the top of the funnel-like portion of the tegmen, the body of the crinoid enlarges to a diameter of 25 mm.

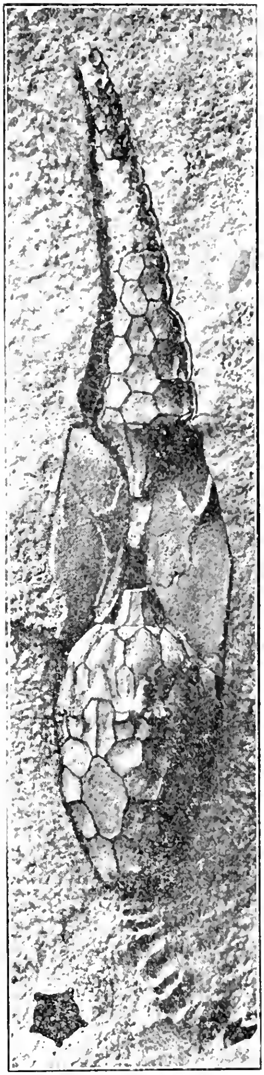


FIGURE 4.

Eucalyptocrinus proboscidialis Miller. Type specimen. An outline of a columnal is added in the lower corner of the figure.

The anal tube rising above the platform of the tegmen is about 15 mm. wide at its base, and tapers gradually to a width of 4 mm. or less. It is composed of hexagonal plates which are almost equilateral at the base but become narrower and smaller farther upward.

At a distance of 15 mm. from the base of the calyx the column consists of columnals 3 mm. in height, intercalated between which are columnals only 1 mm. in height. Toward the base of the calyx, both sets of columnals diminish in height. The general diameter of the column is about 5 mm., but short vertical wing-like processes extend outward from the larger columnals and apparently also from the smaller columnals. In case of the larger columnals these wing-like processes slightly exceed 1 mm. in length. Apparently there are 5 of them within the circumference of each columnal.

The plates of the anal tube are very thick, those near the lower part of the tube varying from 2 to 3 mm. in thickness. The surface of these plates is coarsely and irregularly nodose, especially centrally. From this it is assumed that the plates of the calyx also probably were more or less protuberant centrally, and the

general surface may have been more or less coarsely papillate, but no direct evidence of this is at hand.

Locality and Horizon.—From the Cedarville dolomite at Pontiac, six miles northeast of Piqua, Ohio. The type is numbered 13867 in the Museum of Ohio State University.

Remarks.—In most species of *Eucalyptocrinus* the interdistichal truncates the top of the second costal. In *Eucalyptocrinus proboscidialis* this is prevented by the lateral contact of those first distichals which belong to the same ray. Only two other American species of *Eucalyptocrinus* possessing this characteristic are known. One of these is *Eucalyptocrinus obconicus* Hall, described from the Racine dolomite at Racine, Wisconsin. In the type of this species the vertical height of the calyx is 19 mm., and its diameter at the top is almost seven-tenths of its height. The base of the calyx is obtusely rounded, instead of concave, and the basals may be seen on lateral view of the calyx, though only of short length.

The second of the American species mentioned above was described by Slocom, also under the name *Eucalyptocrinus obconicus* (Field Columbian Mus., 2, Geol. Series, 1908, p. 301, Pl. 86, Figs. 1, 2), though he suspected that it might be distinct. The type of this second species was found in the Racine limestone of the spoil heaps along the Chicago Drainage Canal near Lemont, Illinois. It differs from typical *Eucalyptocrinus obconicus* in being twice as tall and wide; the base of the calyx tapers to an acute angle; the basals are conspicuously taller and narrower; the radials, first costals, and interbrachials also are taller; the combined effect is to produce a more slender appearance along the lower half of the calyx. A cast of the exterior of this specimen shows that the exterior surface of the plates was convex but smooth. For this second species the term *Eucalyptocrinus slocomi* is proposed.

Extended anal tubes, similar to that of *Eucalyptocrinus proboscidialis*, probably occurred also in *Eucalyptocrinus egani*, but the calyx of this species has an impressed base, and the interdistichal truncates the second costal. In species of *Callicrinus* the concavity at the base usually is conspicuously deeper and wider than in typcial *Eucalyptocrinus*.

20. **Periechocrinus cylindricus** Foerste.

(Plate III, Fig. 4.)

Periechocrinus cylindricus Foerste, Ohio Jour. Sci. 17, 1917, p. 244, Pl. 10, Figs. 1 A, B.

In the museum of Wittenberg College, at Springfield, Ohio, there is a calyx of *Periechocrinus cylindricus* nearly 80 mm. in length. Above the distichals the individual plates are not outlined clearly, but it is evident that in the case of each ray that part of the calyx which is directly above the first pair of distichals is somewhat tumid for a height and width of 13 or 14 mm., thus giving the top of the truncated calyx a somewhat pentagonal outline. Since only casts of the interior of the calyx are at hand, it is impossible to determine how large was the column at its attachment with the base of the calyx, but, as far as may be determined from the form of the base of the cast of the interior, the diameter of this column must have been small, almost too small to support a calyx of such large size.

EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Cœlocystis subglobosus* (Hall).

A, anal side, with the two posterior rays, each branched. Small lateral branches of the main food-grooves alternate from side to side of the latter and lead to the facets supporting the brachioles. The margin of the anal orifice protrudes slightly. The attachment area for the column is 10 mm. in diameter. B, viewed from above, with the anal orifice at the top. Both views drawn from a wax cast of the hollow interior of a matrix preserving an impression of the exterior of a complete theca. Only the wax cast is known at present, but the cast shows plainly the presence of the cracks between the original rock fragments. No. 22906, in the Hindshaw collection, in the Walker Museum, at Chicago University. From the Racine dolomite at Chicago, Illinois.

FIG. 2. *Crinocystites chrysalis* Hall.

A, lateral view of cast of interior of an anal tube of some Calyptocrinid, regarded by Hall as the theca of some cystid. B, posterior view of the same. Both figures are reproductions of the figures accompanying the original description, in 20th Rep. New York State Cab. Nat. Hist., 1868, p. 318, Pl. 12a, Figs. 10, 11, but are published in a position inverted as compared with the original to indicate their position in the Calytocrinid. From the Racine dolomite at Racine, Wisconsin. The type, numbered 2023, is preserved in the American Museum of Natural History.

FIG. 3. *Crinocystites chrysalis* Hall.

A, posterior view of cast of interior of an anal tube of some Calyptocrinid. When found this cast of the interior was still attached to the matrix of the specimen used for Figure B, which is an impression of the exterior of the same anal tube. Figure B was drawn from a clay cast of this natural impression. It shows the anterior or slightly concave side of part of the anal tube. The base of this figure shows the upper extensions of the wing-like expansions forming the compartments between which the arms of the Calyptocrinid are folded when at rest. Specimens numbered 22914, from the Hall collection in Walker Museum at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 4. *Eucalyptocrinus proboscidialis* Miller.

Cast of an almost entire specimen, chiefly of the interior, including the dorsal cup, the arching tegmen, constricted between the arms to a narrow tube expanding at the top of the partitions sheltering the arms, surmounted by a long anal tube. Republished from Jour. Cincinnati Soc. Nat. Hist., 5, 1882, p. 224, Pl. 9, Fig. 2, for comparison with that specimen of Crinocystis chrysalis which is used on the present plate for Figure 3B. Original figure prepared from a plaster cast of the original specimen, prepared by D. A. McCord, of Oxford, Ohio. Found in the Cedarville dolomite at Pontiac, south of Sidney, Ohio.

FIG. 5. *Gomphocystites indianensis* Miller.

A, Viewed almost directly from above, but with part of the base showing. Anal aperture a short distance above and toward the left of the mouth. B, Lateral view, with the anal aperture directly beneath the mouth. The exact shape of the base of the specimen is unknown. From the Osgood formation, in Jefferson County, Indiana. Type numbered 6019, in Walker Museum at Chicago University.

FIG. 6. *Gomphocystites bownockeri* Sp. nov.

A, Upper surface of theca, with anal aperture a short distance on the left of the oral aperture. B, Lower part of another specimen showing the ends of two of the rays, drawn so as to indicate the probable form of the complete specimen. There is a possibility that originally these two specimens belonged together, but the broken parts no longer match. Specimens numbered 22943, collected by H. H. Hindshaw, and now in the Walker Museum at Chicago University. From the Racine dolomite at Chicago, Illinois.

Fig. 7. *Hallicystis imago* (Hall).

Lateral view showing the pectinirhomb of Plates 12 and 18, the anal aperture being on the right. This probably is the form for which Jaekel proposed the term Hallicystis elongatus. Specimen numbered 22908 in the Walker Museum of Chicago University. From the Racine dolomite at Chicago, Illinois.

FIG. 8. *Hallicystis imago* (Hall).

A small theca with 5 series of plates, the plates of the middle series not being in contact with each other. Numbered 21734, from the Van Horne collection, in Walker Museum at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 9. *Gomphocystites bownockeri* Sp. nov.

A, Viewed from above, with the anal aperture directly above the oral opening. B, Lateral view, with a glimpse of the anterior ray at the extreme upper left-hand margin of the figure, the tip of the right anterior ray showing at the lower right-hand margin. Numbered 22945, collected by H. H. Hindshaw, and preserved in Walker Museum at Chicago University. Foundin the Racine dolomite in the Bridgeport quarry at Chicago, Illinois.

FIG. 10. *Lysocystites* (?) *nodosus* (Hall).

Exterior of theca. Figure prepared from a clay cast of an impression of the exterior of a specimen in a rock fragment. This impression shows chiefly the characteristics of the exterior but some of the structural features near the surface also have left their traces, especially at the nodes and along the coarser radiating ribs. Specimen numbered 2193, from the James collection in Walker Museum at Chicago University. From the Cedarville dolomite at Wilmington, Ohio.

FIG. 11. *Lysocystites nodosus* (Hall).

A, Cast of interior of theca viewed from above, with anus. The tips of the inverted cuneate elevations of the cast are seen at the lower angles of the five plates belonging to the third series of thecal plates. A single plate intercalated in the third series is in contact with the lower margin of the anal aperture. No fourth series can be recognized. B, lateral view of the same, the cast showing an oblong elevation at the upper end of one of the sutures between the basal plates;

also the characteristic cuneate elevations at the top and bottom of the second series of plates. C, Basal view of the same, showing both the cuneate and the oblong elevations. At the center is a small triradiate structure, of which the median ray points toward the right anterior interradius. The stem appears to have been of remarkably small size. Specimen numbered 21815, from the Van Horne collection in Walker Museum at Chicago University. D, Cast of interior of another specimen, with anal aperture at lower margin of figure, left of the median line. Specimen numbered 18943, from the Gurley collection at Chicago University. From the Racine dolomite at Racine, Wisconsin.

FIG. 12. *Wellerocystis kimmswickensis* Gen. et Sp. nov.

A, Viewed from above, with anus. B, Lateral view, with anus on upper right-hand side, showing that the arm plates occur in single series; along the arm curving around the anal aperture these arm-plates are seen to line only one side of the main food-groove. The arm on the left side of the anal aperture is curved but appears straight from the point of view seen in the figure. A third arm lines the upper left-hand margin of the figure. Specimen numbered 10727, collected by Prof. Stuart Weller, and preserved in Walker Museum of Chicago University. From the Kimmswick limestone near Glen Park, Missouri.

FIG. 13. *Allocystites hammelli* Miller.

A, Viewed from above, with aperture at the top of the figure apparently pentagonal in form and elevated above the general surface of the theca. The transverse ridge near the middle of the figure is interpreted as locating the madreporite. The anal aperture is slightly below the middle of the figure and is more or less quadrangular in outline. B. Specimen numbered 6006, in Walker Museum of Chicago University. From the Osgood formation on Rikers Ridge, northeast of Madison, Indiana.

FIG. 14. *Troostocrinus reinwardti* minimus Var. nov.

Lateral view, with left anterior radial in front. Specimen numbered 14791, collected by Dr. H. E. Wilson, and preserved in Walker Museum of Chicago University. Found 6 miles west of St. Marys, Missouri.

Fig. 15. *Troostocrinus* sp.

Lateral view, with right posterior radial in front. Specimen numbered 22907, from the Van Horne collection,in Walker Museum at Chicago University. From the Racine dolomite at the Bridgeport quarry, at Chicago, Illinois.

FIG. 16. *Troostocrinus sanctipaulensis* Sp. nov.

Lateral view, with right posterior radial in front. Specimen numbered 22909, from the Washburn collection, in Walker Museum at Chicago University. From the top of the Laurel limestone at St. Paul, Indiana.

FIG. 17. *Cyclocystoides* (?) *illinoisensis* Miller and Gurley.

A, Part of the main ring consisting of large plates, with a trace of the surrounding peripheral margin, consisting of small imbricating plates. Type of the species, numbered 6051 A in the collections of Walker Museum at Chicago University; the original of figure 27 on Plate 5 of Bull. 6, Illinois State Mus. Nat. Hist., 1895. Found in the Orchard Creek shale, south of Thebes, Illinois. B, A more complete specimen from the Savage collection at the University of Illinois, found at the same locality and horizon.

FIG. 18. *Savagella ornatus* Savage.

Specimen badly weathered, some of the lower plates of the ring of large plates considerably displaced, but their position indicated by depressions in the rock. Part of the peripheral margin of small imbricating plates preserved. Original of Fig. 28 on Pl. 5, of Bull. 6, Illinois State Mus. Nat. Hist., 1895. From the Orchard Creek shale, south of Thebes, Illinois.

PLATE II.

FIG. 1. *Cœlocystis subglobosus* (Hall).

A, Type, viewed from above. Specimen distorted, with pectinirhomb on plates 14 and 15; apical end crowded toward lower right-hand corner. B, lateral view, showing pectinirhomb on plates 1–5, and 14–15. Specimen numbered 2027 and preserved in the American Museum of Natural History in New York City. From the Racine dolomite at Racine, Wisconsin.

FIG. 2. *Cœlocystis subglobosus* (Hall).

A, Lateral view showing pectinirhomb on Plates 12–18, and along the lower left-hand margin a faint indication of the pectinirhomb on plates 1–5. B, Lateral view, showing anal aperture and pectinirhomb on Plates 12–18. From the Welch collection deposited in Wilmington College, at Wilmington, Ohio. Found in the Cedarville dolomite in the Moodie quarry in that city.

FIG. 3. *Cœlocystis subglobosus* –(Hall).

A, Viewed from above, showing anal aperature and pectinirhombs on plates 14–15 and 12–18, also the divided madreporite plate 23, not numbered in the figure. B, Lateral view, showing the anal aperture and marginal views of the same pectinirhombs. C, Basal view, showing the pectinirhomb on plates 1–5; also the tendency toward a quadrangular outline of the impression produced by the invagination of the basal plates on the cast of the interior. The size of the attachment area for the column is indicated. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 4. *Cœlocystis subglobosus* (Hall).

Oblique lateral view of distorted specimen, showing anal aperture and marginal view of pectinirhomb 12-18. Specimen numbered 1603 in the Illinois State Museum at Springfield, Illinois. From the Racine dolomite at Racine, Wisconsin.

FIG. 5. *Cœlocystis subglobosus* (Hall).

A, Theca viewed from above, showing protruding anal aperture, the pectinirhomb on Plates 14–15, a marginal glimpse of that on plates 12–18, and relatively numerous instances of divided or supplementary plates. B, Same, viewed from in front. D, Same, viewed from the side. C, Basal view of another specimen showing pectinirhomb on plates 1–5; also the quadrangular invaginated base of the cast of the interior. Specimens numbered 35155 and 35061 respectively in the U. S. National Museum at Washington, D. C., the originals of plate diagrams 37 and 36 of Schuchert in his paper on Siluric and Devonic Cystidea and Camarocrinus, Smithsonian Miscellaneous Collections, Vol. 47, Pt. 2, 1904, pp. 248 and 247. From the Racine dolomite at Chicago, Illinois.

FIG. 6. *Callocystites jewetti-elongata* Foerste.

Base of another specimen, showing pectinirhomb on plates 1–5; also large size of attachment area for column. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 7. *Hallicystis imago* (Hall).

A, Lateral view with anal aperture along the margin on the right of the figure, also the pectinirhomb on plates 12–18, and a marginal view of that on plates 1–5 along the lower left-hand margin. B, Lateral view, showing pectinirhomb on plates 1–5. C, Basal view, showing the same pectinirhomb, also the small area for the attachment of the column. From the Cedarville dolomite at Cedarville, Ohio.

FIG. 8. *Cœlocystis subglobosus* (Hall).

Figure prepared from a clay cast of an impression showing part of the width of an entire theca and the attached column. The entire theca was about 4 mm. wider. Even with this increased width the column is relatively very large. Pectinirhomb on plates 1–5, and impressions of the recumbent rays, showing branching. Surface pitted. From the Cedarville dolomite at Springfield, Ohio.

FIG. 9. *Gomphocystites bownockeri* Sp. nov.

A, Lateral view, showing anal aperture, with the left posterior ray along the upper margin of the figure, the right posterior and right anterior rays occurring at successively lower parts of the theca. B, Viewed from above, with anal aperture slightly above and toward the left of the oral aperture. From the Cedarville dolomite at Cedarville, Ohio.

PLATE III.

FIG. 1. *Gomphocystites bownockeri* Sp. nov.

A, Lateral view of an imperfect specimen showing two of the five food-grooves encircling the upper part of the theca in a dextral direction; the lower of these in the figure is the left anterior food-groove; and the upper one is the anterior food-groove. On the right half of the theca, near midheight of the more globose part, is an approximately horizontal series of small plates connecting on the right with the tip of the left posterior food-groove. B, Oblique view of the same specimen showing the two food-grooves mentioned before, above which, in succession, are the right anterior food-groove, and the right posterior one, the latter curving toward the right, close to the left margin of the anal opening, as seen from the point of view of the figure. The pentagonal depression containing the oral aperture is best seen in Figure B. From the Cedarville dolomite at Cedarville, Ohio. No. 8736 in the Museum of Ohio State University.

FIG. 2. *Gomphocystites* sp.

A, Lateral view, showing in succession, from below upward, the left posterior, left anterior, and anterior food-grooves, with a faint view of the right anterior food-groove at the extreme top of the figure. B, View from above, showing four of the food-grooves, the right posterior one curving downward on the right side of the anal aperture, in the figure; then follow in succession the right anterior, anterior and left anterior food-grooves, with the proximal part of the left posterior one indicated on the left side of the right posterior food-groove. The proximal parts of the two posterior food-grooves are not distinctly preserved in the specimen figured and are added here to assist in orienting the specimen. From the base of the Louisville limestone, two miles east of Anchorage, Kentucky.

FIG. 3. *Troostocrinus subcylindricus* (Hall and Whitfield).

A, Type, with the right posterior radial on the left side of the figure. B, Lower half of a theca, with the left anterior radial in the center of the figure. C, Theca with the right posterior radial in the center of the figure. In B and C the truncated basals are angulated along their median lines. From the Cedarville dolomite. A, B, from Yellow Springs, Ohio, are numbered 3306 in the Museum of Ohio State University. C, from Cedarville, Ohio.

FIG. 4. *Periechocrinus cylindricus* Foerste.

Calyx, slightly swollen just beneath the right anterior (RA), right posterior (RP), and left posterior (LP) groups of arms. From the Cedarville dolomite, at Springfield, Ohio. In the Museum of Wittenberg College, at Springfield, Ohio.

FIG. 5. *Cœlocystis subglobosus* (Hall).

Plate diagram of specimen numbered 1603, in the Illinois State Museum of Natural History, in Springfield, Illinois; from the Racine dolomite at Racine, Wisconsin.

FIG. 6. *Cœlocystis subglobosus* (Hall).

Plate diagram of type, numbered 2027 in the American Museum of Natural History in New York City; from the Racine dolomite at Racine, Wisconsin. The dotted lines indicate the parts not distinctly defined in this type.

PLATE IV.

Fig. 1. *Holocystites alternatus* Hall.

Specimen numbered 839 in the Milwaukee public museum, of Milwaukee, Wisconsin. From the Racine limestone at Racine, Wisconsin.

Figs. 2, 3, 4. *Holocystites alternatus* Hall.

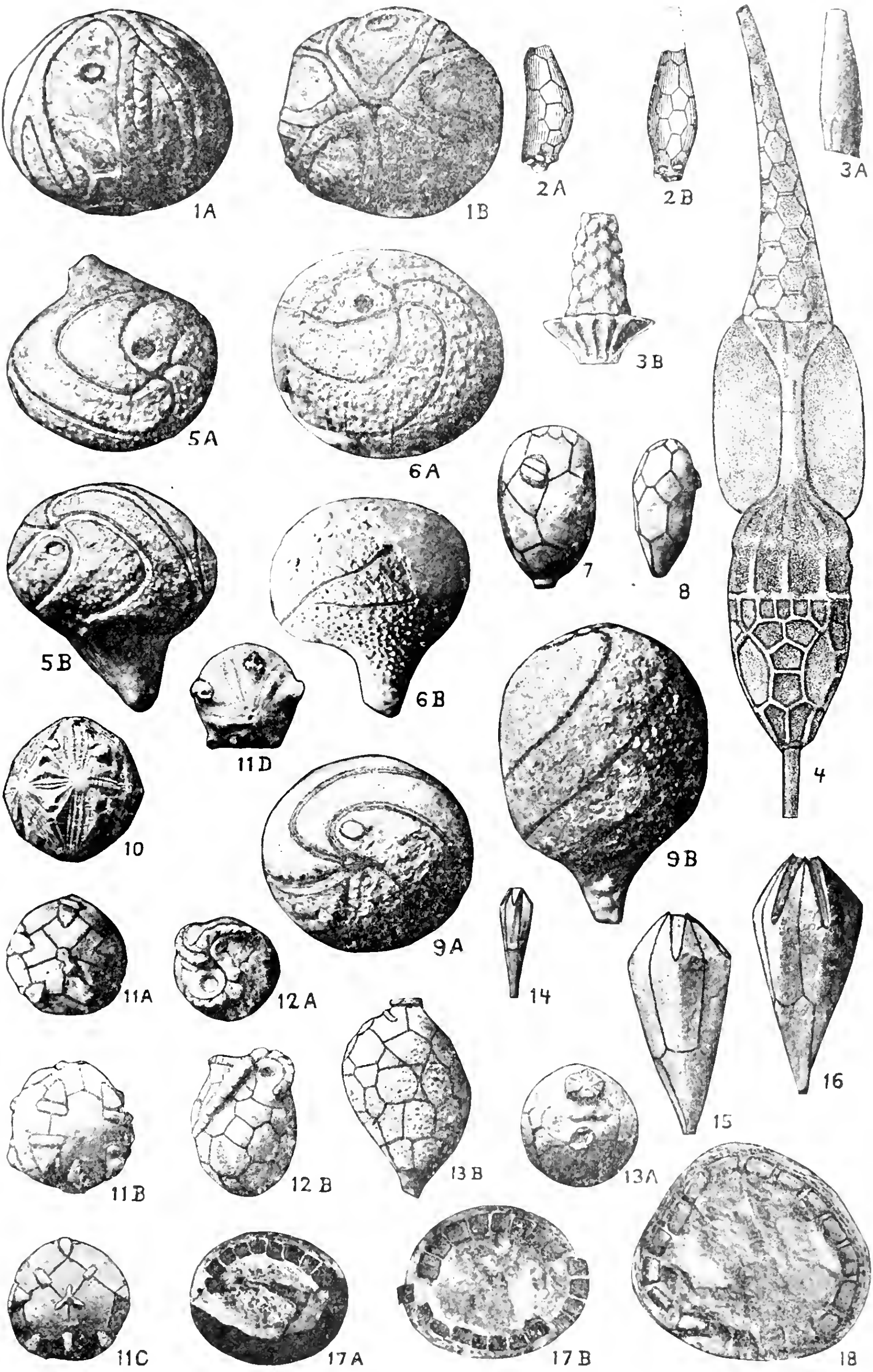
Three specimens from the Cedarville dolomite at Cedarville, Ohio.

Fig. 5. *Holocystites alternatus* Hall.

From the Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection.

Fig. 6. *Holocystites alternatus* Hall.

Type, numbered 2020, in the American Museum of Natural History in New York City. From the Racine dolomite at Racine, Wisconsin. Figure copied from 20th Rep. New York State Cab. Nat. Hist., 1868, Pl. 12a, Fig. 6.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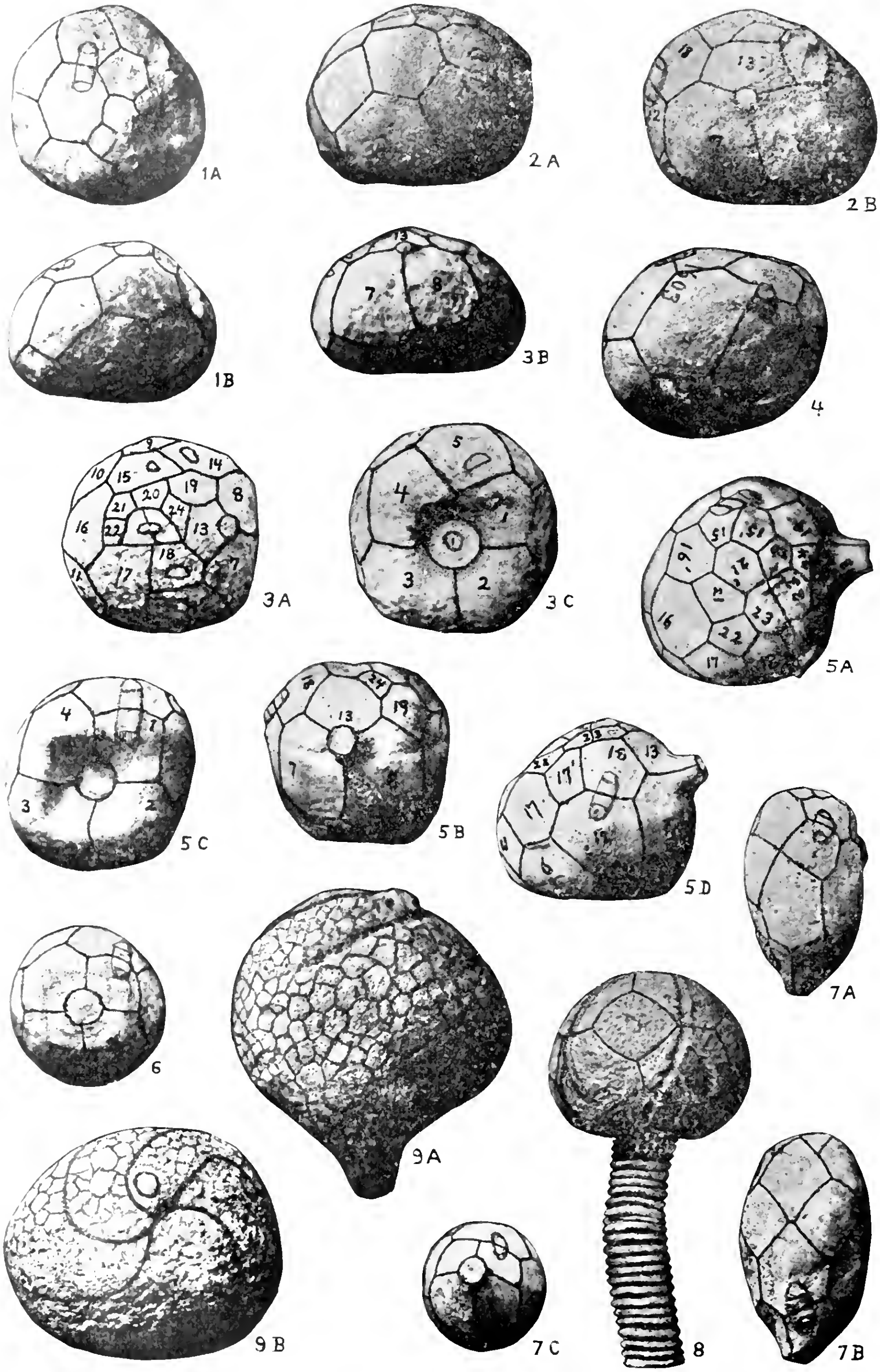
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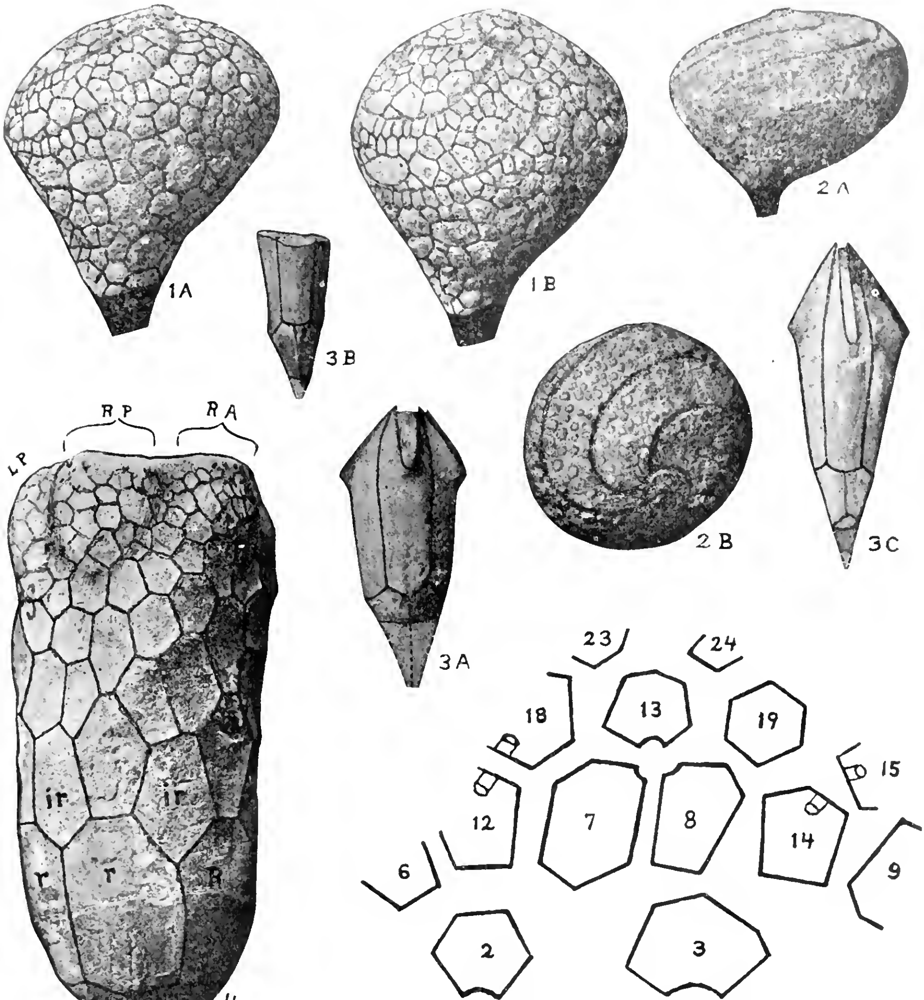
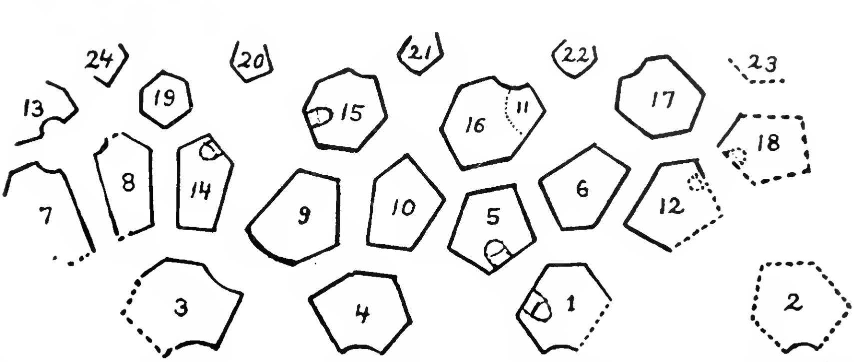
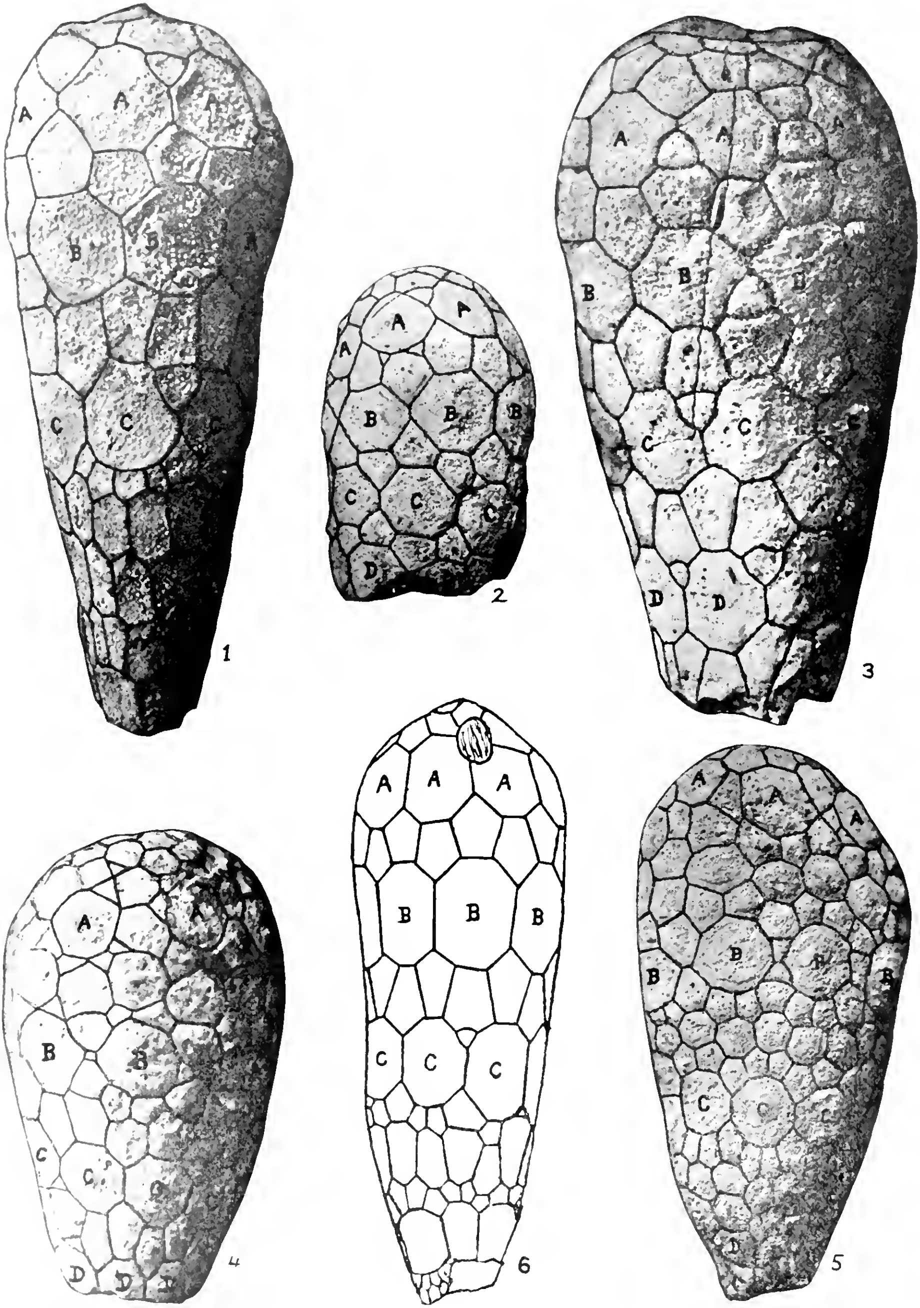


5. COELOCYSTIS SUBGLOBOSUS, 1603.



6. PLATE DIAGRAM OF COELOCYSTIS SUBGLOBOSUS, TYPE, 2027.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FORTY-TWO HITHERTO UNRECOGNIZED GENERA AND SUBGENERA OF ZYGOPTERA.

Clarence Hamilton Kennedy,
Ohio State University.

During the past five years the writer has been engaged in a revision of the genera of the Zygoptera. The following new genera and subgenera have been in manuscript form for from two to five years. In nearly every case the characters of the penis have been the primary indicators that a new generic term might be advisable. In nearly every case other characters, usually venational, were found to parallel the penis characters.

The writer has attempted to give the genus a value which as nearly as possible represents the same amount of differences in whatever part of the Zygopterous series it might fall. This ideal was not altogether attainable, because genera have been split so very fine in the Agrioninæ and some of the other very modern groups. Even in these groups, however, the genera are not as close as in some sections of the Libellulidæ, where connecting links have not yet dropped out.

No apologies are offered for the series of monotypic genera. These in nearly all cases are annectant forms, the last fragments of faunas preceding the present.

Full descriptions of these new genera and subgenera with an extended discussion of their relationships as shown by the genitalia will eventually appear, the author hopes, as a bulletin of the U. S. National Museum.

Vestinus genus nov.

Type—*Vestalis* (*Calopteryx*) *gracilis* Ramb.

This new genus includes *Vestalis amoena* Selys. It differs from *Vestalis* (type *luctuosa*) in that the lobes of the penis are approximated and parallel, M_3 and M_4 arise at the same point on the arculus; there are never two complete rows of cells between Cu_1 and Cu_2 and the wings are hyaline.

Anaciagrion genus nov.

Type—*Agrion* (*Calopteryx*) *cornelia* Selys.

This new genus includes the single beautiful species *cornelia*. It differs from *Agrion* in that Cu_{2a} is 5–6 cells long, as against a length of 2–4 cells in *Agrion* and is directed entad and caudad towards the anal field of the wing.

Euchlorolestes genus nov.

Type—*Chlorolestes fasciata* Selys.

This genus includes also *Chlorolestes tessellata* Burm. and *Chlorolestes longicauda* Burm. Apical soft fold of penis erect and hoodlike; Ac lies slightly distad of the level of the first antenodal.

Episynlestes genus nov.

Type—*Synlestes albicauda* Tilly.

Quadrilateral broad, its inner end one-third of the hind side, first segment of Cu_2 present. Penis with a long attenuate tip.

Ceylonolestes genus nov.

Type—*Austrolestes analis* Ramb.

Includes also *aridus*, *colensonis*, *cyaneus*, *divisus*, *gracilis*, *leda* and *tenuissimus*. Naiad with lateral lobe as in the naiad of *Lestes*, at least so in *analis*. Penis with a spiral strap on the terminal lobe.

Chalcolestes genus nov.

Type—*Lestes viridus* Lind.

Differs from *Lestes* in that the upper segment of the arculus equals the lower and that the penis lacks the internal fold.

Africalestes genus nov.

Type—*Lestes virgatus* Burm.

Venation as in *Chalcolestes*, except that vein M_{1a} is nearly straight throughout its length. Penis with a strap-like inner fold as in *Ceylonolestes*.

Platystigma genus nov.

Type—*Mecistogaster jocaste* Hagen.

Penis with a broad, toothed terminal segment. Dense black part of stigma reduced to one cell in hind wing.

Xanthostigma genus nov.

Type—*Mecistogaster ornatus* Ramb.

Includes *ornatus* and its varieties. Penis with a broad linear terminal segment without lateral teeth. Black part of stigma lacking in both wings.

Haplostigma genus nov.

Type—*Mecistogaster modestus* Selys.

Penis with terminal fold united to the apical segment. Dense part of stigma more than three cells long. Hind wing of male without costal dilation before apex.

Goniostigma genus nov.

Type—*Mecistogaster amalia* Burm.

Costal dilation of male hind wing angulate. Penis with a large internal hood.

Proplatycnemis genus nov.

Type—*Platycnemis* hova Selys.

Includes also *agrioides* Ris. Differs from *Platycnemis* in that M_2 arises at postnodal 6–7 in front wing and at 4 in hind wing and that the stigma is longer than the cell below it.

Leptargia subgenus nov.

Type—*Argia mollis* Hagen.

Includes *fosteri, croceipennis, subapicalis, reclusa, tinctipennis, chapadæ, sociale, smithiana, botacudo, tamoyo, tupi, hasmani, sordida, thespis, tinctipennis.*

Internal soft fold of penis lacking, terminal segment flagellate. South American.

Micrargia subgenus nov.

Type—*Argia thisma* Calvert.

Includes also *lilacina.* Terminal segment of penis saggitate.

Heliargia subgenus nov.

Type—*Argia vivida* Hagen.

Includes also *plana, funebris, immunda, deami,* probably also *talamanca, underwoodi* and *terira.*

Internal fold of penis small or wanting, terminal segment irregularly triangular or even with a short attenuate tip. External fold present.

Cyanargia subgenus nov.

Type—*Argia lacrymans* Hagen.

Includes also *tonto.* Penis with a flagellum attached to inner surface of terminal segment.

Chalcargia subgenus nov.

Type—*Argia oenea* Hagen.

Includes also *orichalcea, harknessi, barreti, calida, percellulata, insipida, ulmeca, adamsi, pipila, oculata, difficilis, rogersi, jocosa, tezpi, translata, sedula, gerhardi, frequentula, cuprea, pulla, nigrior, indicatrix, gaumeri, popoluca, cupraurea, johanella.*

Penis with apex bifid.

Argyrocnemis genus nov.

Type—*Agriocnemis argentea* Tillyard.

Penis with edges of terminal segment serrate, male superior appendages with hollow tips.

Neoerythromma genus nov.

Type—*Enallagma cultellatum* Selys.

Penis characters as in *Erythromma*, but male appendages resembling those in *Enallagma signatum*.

Psenderythromma genus nov.

Type—*Erythromma viridulum* Charp.

Like *Erythromma* except male appendages *Psendagrion*-like and wing with only 10–11 postnodals and 3 antenodal ultra-quadrilateral cells.

Austrocoenagrion genus nov.

Type—*Coenagrion lyelli* Tilly.

Like *Coenagrion* except penis with shaft spines and the internal soft fold hood-like. Venation not studied.

Hawaiiagrion genus nov.

Type—*Megalagrion* (*Coenagrion*) *xanthomelas* Selys.

Characters as in *Coenagrion*, but colors are reds and yellows, and the male appendages are *Psendagrion*-like. Includes *deceptor*, *calliphya*, *nigrohamatum*, *vagabundum*, *molokaiense*, *microdemas* and others.

Kilauagrion genus nov.

Type—*Megalagrion* (*Coenagrion*) *nesiotes* Perkins.

Generic characters as in *Hawaiiagrion*, except that the male superiors are long and forcipate.

Oahuagrion genus nov.

Type—*Megalagrion* (*Coenagrion*) *oahuense* Blackburn.

Generic characters as in *Hawaiiagrion* except that the stigma in hind wing of male is placed one and a half times as far from the wing apex as is the stigma of the front wing, slightly less so in the female.

Apanisagrion genus nov.

Type—*Anisagrion lais* Selys.

Characters as in *Anisagrion*, except that the wing is not petioled to Ac by a distance equal to the length of Ac and the apex of segment 10 in the male is not forked.

Protallagma genus nov.

Type—*Amphiagrion titcacæ* Calvert.

Characters as in *Enallagma*, except that the colors are largely red and the apex of segment 10 in the male is merely notched; i. e., without the two tubercles.

Oxyallagma genus nov.

Type—*Oxyagrion dissidens* Selys.

Characters as in *Enallagma*, except red a dominant color, no postocular spots and penis without lateral basal lobes.

Africallagma genus nov.

Type—*Enallagma glaucum* Burm.

Generic characters as in *Enallagma*, except apex of segment 10 in male is elevated into an apical keel, notched at apex. Includes *nigridorsum*, *obliteratum* and *schultzei* as described by Ris, "Od. Sudafrika."

Cyanallagma genus nov.

Type—*Acanthagrion interruptum* Selys.

Characters as in *Acanthagrion*, except the male superior appendages not decurved from the base and are usually forked.

Includes *laterale*, *acutum* and perhaps *cheliferum*.

Archaeallagma genus nov.

Type—*Enallagma ovigerum* Calvert.

Characters as in *Enallagma*, except that the hind edge of the prothorax with a rectangular lobe.

Mesamphiagrion genus nov.

Type—*Enallagma occultum* Ris.

Characters as in *Enallagma*, but body colors red, apex of segment 10 elevated and notched, body long haired and stigma one-half cell long. Differs from *Amphiagrion* in male appendages being *Enallagma*-like, in postocular spots, in lacking the metasternal tubercles.

Teleallagma genus nov.

Type—*Telagrion daecki* Calvert.

Characters as in *Enallagma*, but the pair of subdorsal apical points of segment 10 are widened laterally into minute lobes, abdomen very slender. Wings petioled to Ac.

Ischnallagma genus nov.

Type—*Ischnura elongata* Martin.

Venation and stigmas as in *Ischnura*, apex of ten forked, male appendages and penis as in *Enallagma*.

Proischnura genus nov.

Type—*Enallagma subfurcatum* Selys.

Characters as in *Enallagma*, except stigmas of hind wings smaller than those of front wings. Apex of segment 10 in male

forked. Penis intermediate between that of *Ischnura* and that of *Enallagma*.

Homeoura genus nov.

Type—*Ischnura neops* Selys.

Characters as in *Ischnura*, but more Enallagmine. Proximal and distal sides of stigmas rounded, costa slightly indent d at stigma. Penis with large lateral paches of spines on the second segment.

Anomalura genus nov.

Type—*Ischnura prognatha* Hagen.

Characters as in *Ischnura*, except the apical fork of segment 10 in the male is elongated into a spine, the paired spines of the penis are external as in *Anomalagrion*.

Nanosura genus nov.

Type—*Ischnura aurora* Braner.

Characters as in *Ischnura*, except male with a pair of mesothoracic hook-like horns.

Amphiallagma genus nov.

Type—*Enallagma parvum*.

Characters as in *Amphiagrion*, except post ocular spots present, colors blue and black; body not heavily haired.

Seychellibasis genus nov.

Type—*Telebasis allaudi* Martin.

Characters as in *Teinobasis*, except anal plate in male not elongate. Apical lobe of penis linear.

Palaeobasis genus nov.

Type—*Pyrrhosoma tenellum* Vill.

Characters as in *Ceriagrion*, except that wings are not petioled to Ac.

Diceratobasis genus nov.

Type—*Agrion macrogaster* Selys.

Characters as in *Metaleptobasis*, but male without thoracic horns, while a large pair of horns occur on the seminal vesicle.

Aceratobasis genus nov.

Type—*Metaleptobasis cornicauda* Calvert.

Characters as in *Metaleptobasis*, but male without thoracic horns and his superiors longer than the inferiors.

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SEASONAL CHANGES AND TRANSLOCATION OF CARBOHYDRATE MATERIALS IN FRUIT SPURS AND TWO-YEAR-OLD SEEDLINGS OF APPLE.*†

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At the suggestion of Prof. W. Paddock, of the Department of Horticulture of the Ohio State University, the writer undertook the work of determining the changes in carbohydrate content of fruit spurs and two-year-old seedlings of apple throughout the year. The work was done under the direction of Dr. H. C. Sampson, of the Department of Botny, and with the assistance of Dr. T. G. Phillips and Dr. J. F. Lyman, of the Department of Agricultural Chemistry.

This is a part of the larger problem of determining what effect the carbohydrate content of fruit spurs has upon vegetative growth and reproduction, and to what extent it should be considered in handling fruit trees.

The methods used in the analysis of plant materials were as follows: The samples were collected from the campus orchard and nursery every two weeks and a quantitative analysis was made in every case to determine the percentage of starch and the sugars, sucrose, glucose, and maltose. For the determination of starch the method described by Abderhalden[5] was followed, and for sugars, that described by Darwin and Acton[4], with a slight modification. In both cases the quantity of dextrose was determined by Fehling's solution, titrating against a standard potassium permanganate solution, as has been approved by the Association of Official Agricultural Chemists.[3] In the case of two-year-old seedl ngs, separate analyses were made on the one-year-old stem segments, two-year-old stem segments, and roots. All percentages are expressed on a dry weight basis.

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*Paper read at the Thirtieth Annual Meeting of the Ohio Academy of Science, May 15, 1920, Columbus, Ohio.
†Papers from the Department of Botany, Onio State University, No. 121.

The earliest work on the study of translocation of starch is that of Mer.[1] This investigator made a thorough study of the changes of starch content throughout the growing and dormant periods of the year in different parts of the tissues, both in ordinary and girdled stems of various plants, such as beech, oak, pine, etc. Similar investigations were made by Rosenberg.[2] The most recent work is that of Butler, et al,[7] who made a thorough analytical study of the carbohydrate, nitrogen, fats, phosphorus, and potassium of different parts of bearing

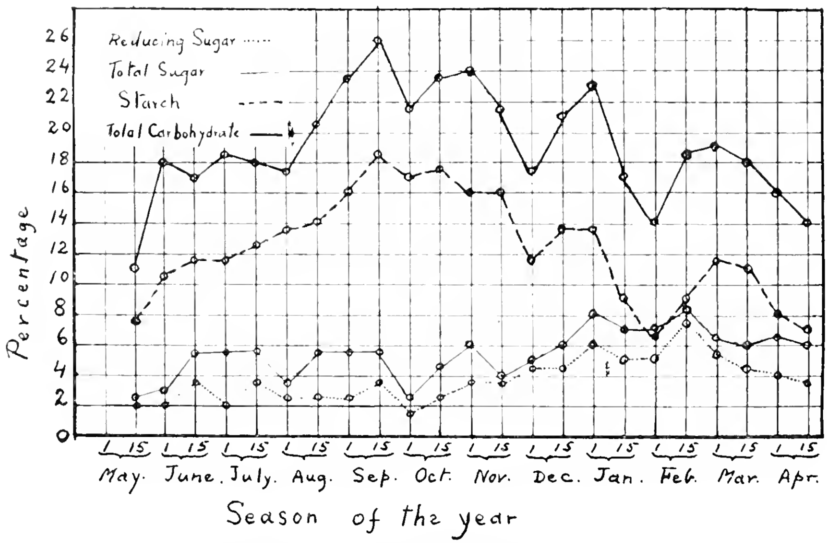

Fig. 1. Curves showing changes in carbohydrates in fruit spurs of apple from May to April, 1919–1920. The ordinates represent the percentage of carbohydrates and the abscissae, the season of the year.

apple trees. The writer's work is similar to that of the latter investigators, so far as the carbohydrate materials are concerned. There is, however, some disagreement in the data obtained in the two cases. This is, perhaps, due to the difference in age and in location of the trees in different climatic conditions. The data presented in this report show a seasonal periodicity in the changes of the carbohydrate materials, i. e., starch to sugar and vice versa, and a partial explanation of the factors that bring about these changes. The data also show that changes in temperature play a very important part in the changes of carbohydrates in plant tissues. The fluctuations

of temperature during the growing and dormant periods are accompanied by changes in acidity in the plant, which in turn affect the activity of the enzymes which have always been found by actual experiment to be present at all seasons of the year.

The data of the analyses are presented under three headings: First, curves showing changes in carbohydrates in fruit spurs; second, curves showing changes in carbohydrates in two-year-old seedlings; third, curves showing acidity in both the fruit spurs and seedlings. The curves in each case are followed by a brief summary and discussion.

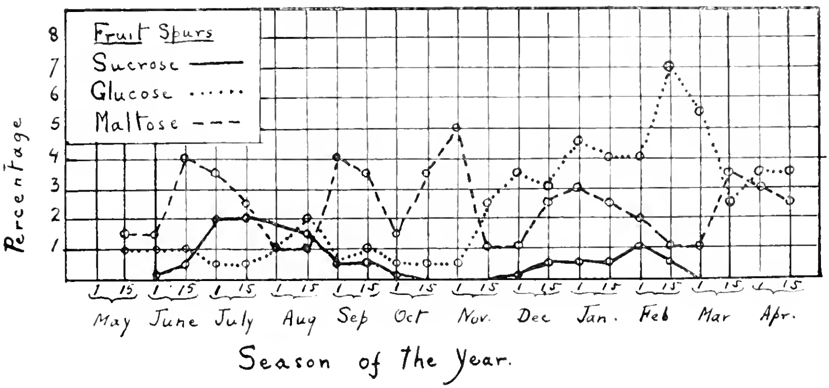

Fig. 2. Curves showing the percentage of sucrose, glucose and maltose in fruit spurs of apple from May to April, 1919–1920. The ordinates represent the percentage of sugars and the abscissae, the season of the year.

The Fruit Spurs.

1. Change of temperature has a marked bearing on the translocation of carbohydrate materials in fruit spurs of apple.

2. The accumulation of both total carbohydrate and starch shows marked increase during August and September, the maximum accumulation occurring in September.

3. As the temperature decreases in autumn the starch content decreases without any marked increase in either the total or reducing sugars. This decrease of starch continues until February, when it reaches its maximum for the dormant season. The total carbohydrate content of the fruit spurs follows a similar course.

4. Most of the hydrolysed starch is either utilized in metabolic processes or transferred to the adjacent parts of the stem, as is evidenced by the change in the total carbohydrate content of fruit spurs. This occurs during the dormant period when metabolic processes are at a minimum. There is also a possibility that some of the carbohydrates are used in fat synthesis or other syntheses at this time, but no data were obtained on this point.

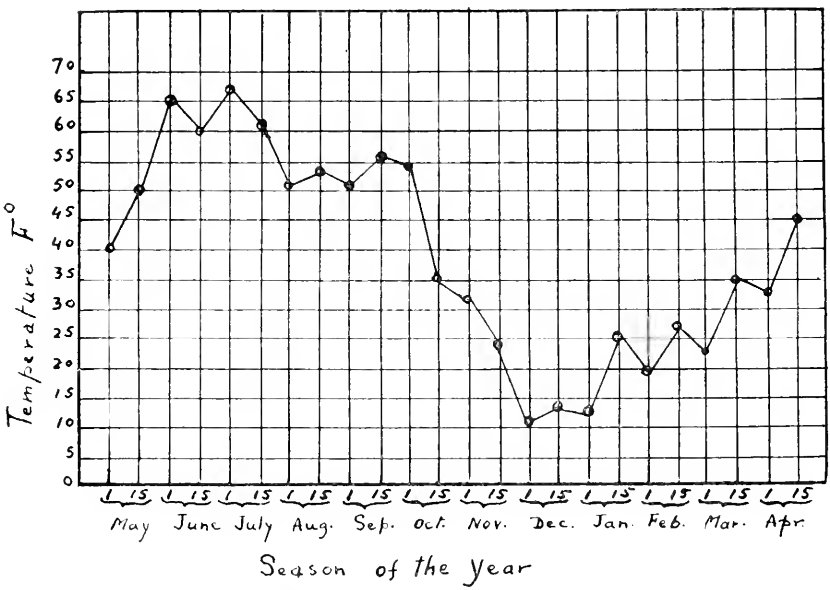

Fig. 3. A curve showing the average minimum temperature of the campus (Ohio State University) from May to April, 1919–1920. The ordinate represents the temperature in F° and the abscissa, the season of the year.

5. In the early spring, especially in March and April, during the swelling of buds and the early growth of leaves and flowers, the starch and sugars disappear very rapidly, apparently being utilised in the formation of new growth and the respiration of the growing cells.

6. The total sugar, especially reducing sugars, increases in December and is at its maximum during December, January and February. This increase of total sugar does not account quantitatively for the decrease of starch during the dormant period.

7. The translocation of sugars in apple spurs is largely in the form of glucose and maltose. Glucose appears to be the most important sugar of translocation during the dormant period.

8. Maltose appears to be the most important sugar of translocation during starch accumulation in autumn. To sum up, the upward translocation of sugar in spring is largely in the form of glucose, while the translocation of sugar from leaves to stem in autumn is largely in the form of maltose.

9. The quantity of sucrose is very small in comparison to glucose and maltose. In fruit spurs it is found in the early growing and dormant period and is almost lacking at other times.

10. The process of downward translocation of sugar is very slow in comparison to the upward translocation, the latter of which is influenced by the transpiration stream during the early spring.

11. The correlation between the changes in acidity and the resultant effect upon the enzymes involved and the changes in carbohydrates in fruit spurs will be discussed later.

The Two-year-old Apple Seedlings.

1. The effect of temperature upon the changes and translocation of carbohydrates in apple seedlings is similar to its effect on carbohydrates in the fruit spurs of apple.

2. Total carbohydrate accumulation increases rapidly in both stems and roots at the close of the growing period in August, September and October, followed by a slight increase in roots and two-year-old stems, the maximum being reached in October, after which a gradual decrease follows.

3. After December there is a marked decrease in total carbohydrate both in roots and stems, which reaches its minimum in January, February and March. This decrease is perhaps due to slow metabolic processes, such as respiration, and also to a change of carbohydrates to non-carbohydrate materials, such as fats. There is also a marked development of latex-like material in the roots during January and February. Butler, et. al.* have found a slight increase of fats in roots and two-year-old branches during the dormant period. The latex material

*Loc. Cit.

was not analysed. It disappears by the middle of February, at which time the total carbohydrate material increases slightly. A marked decrease of carbohydrate occurs during the growing period of April, May and June.

4. The starch content of roots and stems increases rapidly with the decrease of growth in autumn, following a course

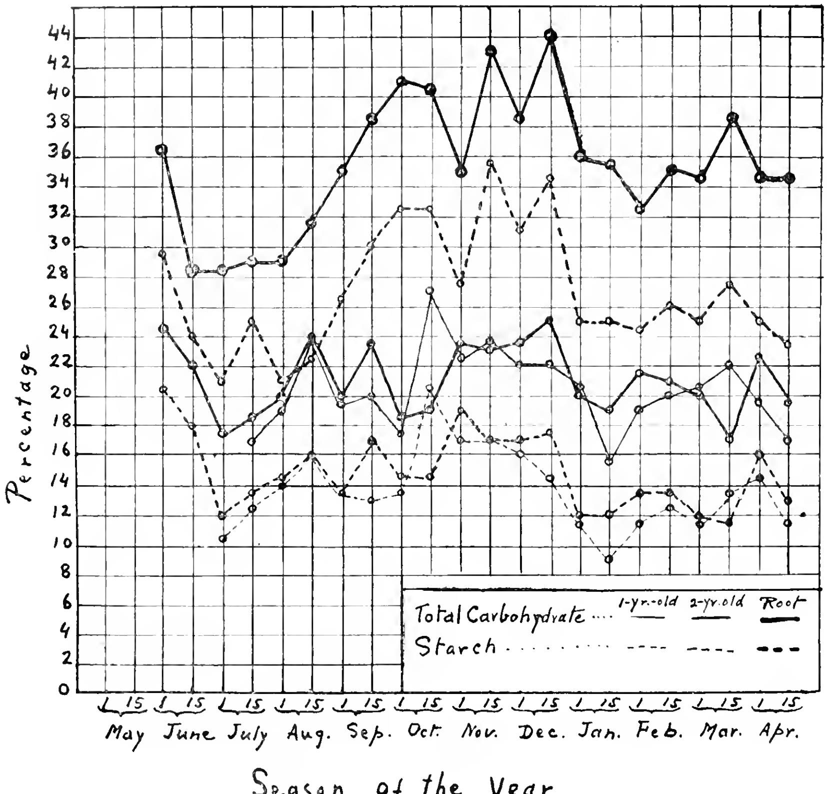

Fig. 4. Curves showing the changes in carbohydrates in two-year-old seedlings of apple from June to April, 1919–1920. The ordinates represents the percentage of carbohydrates and the abscissae, the season of the year

parallel to that of total carbohydrate in each case. The increase of starch in roots is much greater than that in stems. In one- and two-year-old stems the maximum is reached in October and November, followed by a gradual decrease, while in the case of roots the maximum accumulation of starch occurs in December, after which there is a rapid fall. The minimum

starch content during the dormant period in stems and roots occurs from January to March, after which there is a gradual increase until the inception of growth in spring.

5. This decrease of starch during the dormant period is due partly to hydrolyzation to sugar and probably to slow respiration, and in the case of roots to the formation of latex-like material, as already mentioned. There is a possibility of some

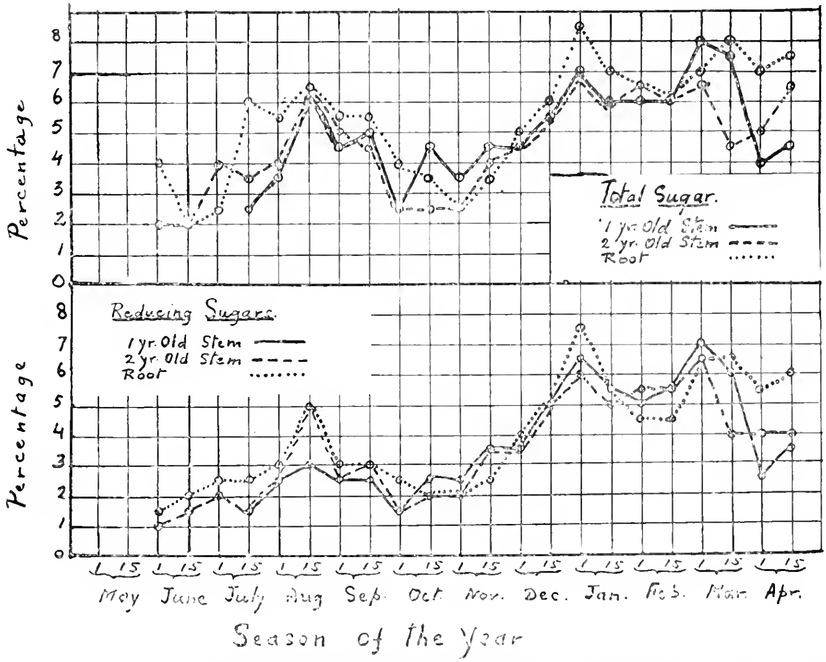

Fig. 5. Curves showing the percentage of total sugar and reducing sugars in two-year-old seedlings of apple from June to April, 1919–1920. The ordinates represent the percentage of carbohydrates and the abscissae, the season of the year.

fat or other synthesis. With the swelling of buds in the spring a general decrease of starch and total carbohydrate occurs in all parts of the plant.

6. The role played by the different sugars is similar to that described in the case of fruit spurs. Glucose and maltose are the principal sugars of translocation. Glucose reaches its maximum during the dormant period in all parts of the plant. It decreases in stems very rapidly during the early spring and increases in roots until April and then decreases owing to its

upward translocation and root growth. It is apparently the most important sugar of upward translocation in spring.

7. Maltose reaches its maximum in both stems and roots during summer and autumn at the time of translocation of

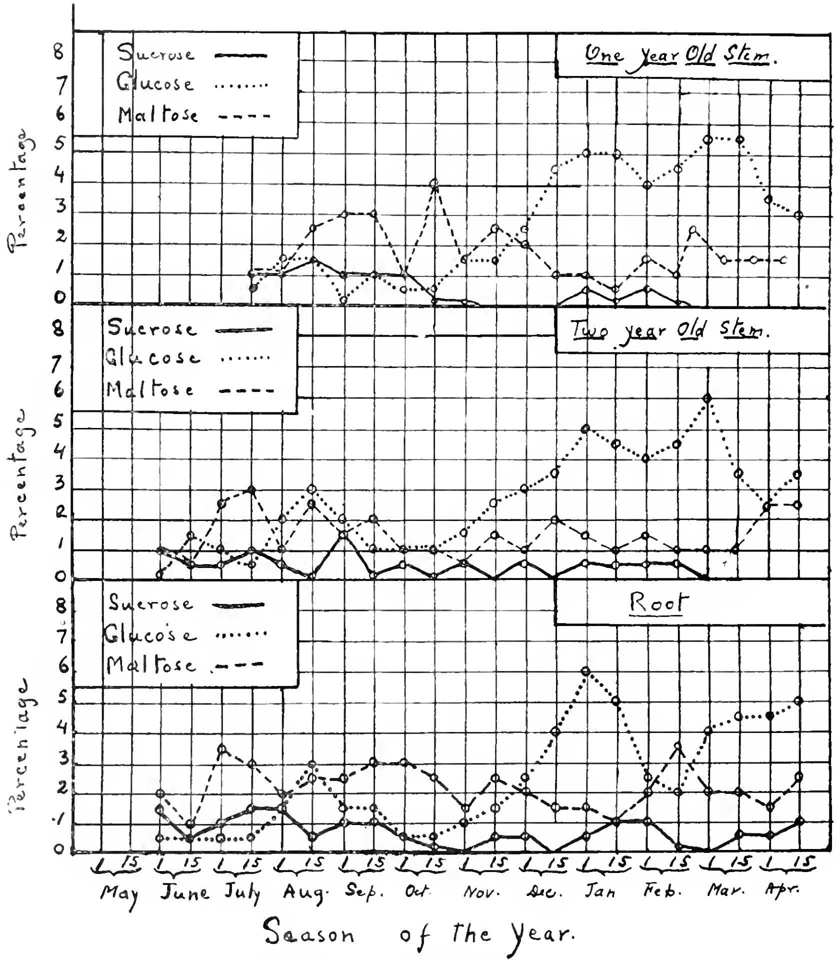

Fig. 6. Curves showing the percentage of sucrose, glucose and maltose in two-year-old seedlings of apple from June to April, 1919–1920. The ordinates represent the percentage of carbohydrates and the abscissae, the season of the year.

sugars from the leaves. It is very low in stems during the dormant period, but increases slightly with the rise of sap in spring.

8. Sucrose is very low in comparison to glucose and maltose. Its maximum occurs in all parts of the plants during summer and autumn. Its presence in roots is more pronounced than in the stems, which has also been shown by Butler et al. It is not an important storage sugar in seedlings.

9. It is interesting to note that the amount of sugars in both stems and roots runs a close parallel throughout the year, with the exception of a greater content in roots during early spring.

10. The total sugar and the reducing sugars in both stems and roots show parallel curves. There is a marked increase at the beginning of the dormant season, which reaches its maximum from January to March, when the starch content is at a minimum. During the dormant period there is a marked hydrolysis of starch to sugar and a partial resynthesis of this sugar to non-carbohydrate compounds.

11. Total carbohydrate in roots is twice as much as that found in one and two-year-old stems, which are almost identical in their carbohydrate content.

The Acidity of Fruit Spurs and Two-year-old Seedlings of Apple.

1. Acidity is high in summer and low in winter. In general during the growing period all parts of the seedlings are distinctly acid, while during the dormant period they approach close to neutrality. The roots and two-year-old stems become slightly alkaline during February and March, after which there is a rapid rise in acidity.

2. Acidity is highest in the leaves and lowest in the roots. The acidity of the leaves is on the decline at the time of abscission.

3. Acidity of the one-year-old stems and the fruit spurs used in the experiments is identical.

4. There is an approximate correlation between the optimum hydrogen ion concentration for the hydrolytic action of plant diastases (about $10^{-4.5}$, Sherman et al.)[8] and maltase ($10^{-6.6}$, Hober[6]) and the time of the most active hydrolyzation of starch in the fruit spurs and stems, i. e., during the dormant period beginning with November. The correlation is not so clear in the case of hydrolysis in roots. Further data on this point are needed.

5. There is also a general correlation between the H ion concentration and the relative activity of diastase and maltase and the consequent concentration of glucose and maltose in the tissues. The optimum H ion concentration for diastase is somewhat more acid than for maltase.

6. Maltose is most abundant and glucose is least abundant in summer and autumn, when acidity is highest and nearer the optimum for diastase than for maltase. On the other

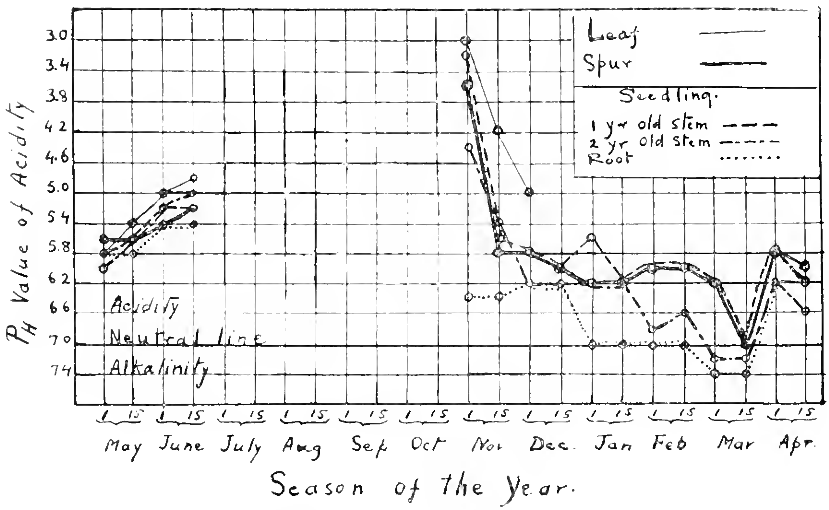

Fig. 7. Curves showing the seasonal changes in PH value of acidity in fruit spurs and two-year-old seedlings of apple from November to June, 1919–1920. The ordinates represent the acidity in PH and the abscissae, the season of the year. Unfortunately, no data were obtained from July to October.

hand, maltose is lowest and glucose is highest during the dormant period, when acidity is lowest and nearer the optimum for maltase than for diastase. The maltose is thus hydrolyzed to glucose at this time almost as rapidly as it is formed from starch. These facts suggest an explanation of why maltose is the most important sugar of translocation from leaves to stem in summer, while glucose is the most important sugar of translocation from root to stem at the close of the dormant period.

7. The presence of invertase has been found by experiment to be much more in abundance in the tissues of fruit spurs and seedlings than either diastase or maltase. It is for this reason that sucrose is rapidly hydrolysed in October and November,

when the acidity is nearer to the optimum activity of invertase (about 10^{4511}, Hober). Sucrose is mostly at its highest during the growing period and early dormant period, when the acidity is rather below the optimum for sucrase. In fact, the data on acidity show in general a correlation of acidity to the activity of enzymes that are involved in the changes of the carbohydrate materials and their accumulation in plant tissues.

The writer is indebted to Professors J. F. Lyman and T. G. Phillips for helpful suggestions in analytical work and especially to Prof. H. C. Sampson for numerous suggestions on problems and interpretation of results.

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ANALYSIS OF FRUIT SPURS OF APPLE (DRY BASIS).

Date	Starch	Sucrose	Maltose	Glucose	Total Sugar
May 15	7.470	.....	1.438	1.214	2.720
June 1	10.580	.190	1.531	1.152	2.960
" 15	11.439	.252	3.960	.905	5.333
July 1	11.459	2.166	3.258	.378	5.533
" 15	12.459	2.052	2.628	.349	5.266
Aug. 1	13.500	.....	1.234	1.218	3.086
" 15	13.815	1.531	1.073	1.871	5.266
Sept. 1	16.214	.502	4.020	.508	5.266
" 15	18.599	.507	3.401	1.258	5.266
Oct. 1	17.100	.126	1.700	.636	2.543
" 15	17.399	.....	3.403	.558	4.400
Nov. 1	16.200	.....	4.950	.597	5.800
" 15	15.899	.....	1.328	2.696	4.066
Dec. 1	11.459	.127	.928	3.696	4.800
" 15	13.500	.443	2.628	2.909	6.133
Jan. 1	13.500	.696	2.939	4.317	8.133
" 15	8.879	.468	2.541	4.092	7.233
Feb. 1	6.300	.950	2.011	3.887	6.933
" 15	8.879	.443	.928	6.963	8.400
Mar. 1	11.459	.....	.772	5.323	6.533
" 15	10.899	.....	3.387	2.571	6.133
April 1	8.259	.....	2.996	3.492	6.568
" 15	6.899	.....	2.560	3.688	6.091

ANALYSIS OF TWO-YEAR-OLD SEEDLINGS OF APPLE (DRY BASIS).

Date	Starch	Sucrose	Maltose	Glucose	Total Sugar
June 1–1*	......	.....	.....	.....	.....
" 1–2	20.279	.772	1.111	.152	2.213
" 1–2	29.399	1.342	2.041	.389	3.920
" 15–1	......	.....	.....	.....	.....
" 15–2	17.759	.253	.679	1.238	2.213
" 15–3	23.999	.251	.752	.608	1.653
July 1–1	10.399	.....	.....	.....	.....
" 1–2	11.999	.393	2.628	.963	4.133
" 1–3	29.999	1.077	3.401	.558	5.266
" 15–1	12.699	.840	.958	.526	2.666
" 15–2	13.500	.822	2.889	.267	3.533
" 15–3	21.899	1.647	3.248	.658	5.800
Aug. 1–1	14.088	.750	1.236	1.491	3.533
" 1–2	14.699	.570	1.238	1.904	3.800
" 1–3	20.999	1.648	2.320	1.362	5.533
" 15–1	16.204	1.582	2.630	1.370	5.800
" 15–2	15.899	.190	2.628	3.042	6.133
" 15–3	22.500	.442	2.630	3.170	6.400

* 1 = One-year-old stem. 2 = Two-year-old stem. 3 = Root.

ANALYSIS OF TWO-YEAR-OLD SEEDLINGS OF APPLE (DRY BASIS).
(Continued.)

Date	Starch	Sucrose	Maltose	Glucose	Total Sugar
Sept. 1-1......	13.500	.750	3.248	.235	4.400
" 1-2......	13.699	1.617	1.392	1.805	5.000
" 1-3......	26.450	1.077	2.628	4.612	5.533
" 15-1......	13.299	1.077	2.784	.943	5.000
" 15-2......	17.100	.253	2.011	1.178	4.400
" 15-3......	29.800	.823	3.248	1.258	5.433
Oct. 1-1......	13.500	.823	.958	517	2.386
" 1-2......	14.699	.409	958	944	2.386
" 1-3......	32.699	.278	2.909	455	3.800
" 15-1......	20.250	.228	3.804	.366	4.500
" 15-2......	14.699	.126	1.020	1.045	2.546
" 15-3......	32.699	.236	2.350	.516	3.266
Nov. 1-1......	17.100	.152	1.670	1.355	3.266
" 1-2......	18.900	.705	.308	1.630	2.386
" 1-3......	27.299	....	1.331	1.182	2.680
" 15-1......	17.100	....	2.320	1.138	4.533
" 15-2......	17.100	....	1.392	2.672	4.133
" 15-3......	35.399	.266	2.626	1.384	3.666
Dec. 1-1......	15.899	....	2.011	2.287	4.400
" 1-2......	17.100	.316	1.236	3.038	4.652
" 1-3......	29.999	.316	2.011	2.554	5.000
" 15-1......	14.699	....	1.160	4.281	5.500
" 15-2......	17.739	....	1.934	3.470	5.500
" 15-3......	34.538	....	1.547	4.179	5.800
Jan. 1-1......	11.469	.570	1.236	4.771	6.866
" 1-2......	11.999	.396	1.545	4.892	6.916
" 1-3......	24.899	.712	1.547	5.989	8.333
" 15-1......	8.879	.127	467	5.235	5.833
" 15-2......	11.999	.571	.772	4.409	5.833
" 15-3......	24.899	.905	765	5.162	6.916
Feb. 1-1......	11.469	.348	1.468	3.790	6.133
" 1-2......	13.500	.507	1.392	3.988	6.400
" 1-3......	23.599	1.076	2.011	2.551	6.400
" 15-1......	12.638	.127	.928	4.696	5.800
" 15-2......	13.500	.507	.772	4.709	6.133
" 15-3......	26.100	.126	3.712	2.100	6.133
Mar. 1-1......	11.459	....	2.591	5.378	8.000
" 1-2......	11.999	....	.772	5.943	6.733
" 1-3......	24.899	....	2.532	4.202	6.916
" 15-1......	13.500	....	1.530	5.320	6.916
" 15-2......	11.459	....	772	3.656	4.400
" 15-3......	27.599	.627	2.514	4.696	8.000
April 1-1......	14.699	....	1.663	3.431	4.183
" 1-2......	15.899	....	2.320	2.312	4.750
" 1-3......	24.899	.712	1.531	4.552	6.916
" 15-1......	11.455	....	2.624	3.562	6.390
" 15-2......	12.860	....	2.624	3.560	6.390
" 15-3......	23.599	.876	2.610	4.806	7.668

PERCENTAGE OF REDUCING SUGARS IN FRUIT SPURS AND TWO-YEAR-OLD SEEDLINGS OF APPLE (DRY BASIS).

Date	Spurs	Seedlings		
		1-Yr.-Old Stem	2-Yr.-Old Stem	Roots
May 15...	2.100	.....	.....	.....
June 1...	.....	.820	.820	1.635
" 15...	3.360	.....	1.653	1.866
July 1...	2.100	.....	2.253	2.666
" 15...	3.360	1.400	1.686	2.666
Aug. 1...	2.386	2.253	2.666	2.800
" 15...	2.546	3.000	4.800	4.800
Sept. 1...	2.666	2.253	2.666	3.233
" 15...	3.266	2.666	3.233	3.233
Oct. 1...	1.680	1.660	1.533	2.253
" 15...	2.666	2.720	1.973	1.813
Nov. 1...	3.666	2.386	1.813	2.106
" 15...	3.400	3.533	3.533	2.253
Dec. 1...	4.266	3.533	3.533	3.800
" 15...	4.533	5.000	5.000	5.000
Jan. 1...	6.133	6.616	5.833	7.250
" 15...	5.000	5.500	4.750	5.666
Feb. 1....	4.800	5.000	5.266	4.400
" 15....	7.533	5.266	5.266	4.400
Mar. 1...	5.500	6.983	6.400	5.833
" 15....	4.666	6.150	4.183	6.250
April 1....	3.950	2.466	3.750	5.500
" 15...	3.450	3.012	4.183	6.000

PERCENTAGE OF TOTAL CARBOHYDRATE IN TERMS OF GLUCOSE.

Date	Spurs	Seedlings		
		1-Yr.-Old Stem	2-Yr.-Old Stem	Root
May 15...	11.042	......	......	......
June 1...	17.900	......	24.743	36.525
" 15...	16.975	......	21.945	28.318
July 1....	18.265	......	17.465	28.598
" 15....	17.998	16.776	18.533	28.198
Aug. 1...	17.386	19.186	20.132	28.865
" 15....	20.616	23.804	23.798	31.400
Sept. 1....	23.281	19.400	20.201	34.921
" 15....	25.931	19.776	23.400	38.644
Oct. 1....	21.543	17.386	18.718	40.132
" 15....	23.732	27.000	18.876	39.598
Nov. 1....	23.800	22.266	23.386	33.012
" 15...	21.331	23.533	23.133	42.999
Dec. 1....	17.532	22.065	23.652	38.332
" 15....	21.133	21.832	25.210	44.175
Jan. 1...	23.133	20.552	20.248	35.988
" 15....	17.098	15.698	19.165	35.581
Feb. 1....	13.933	18.876	21.400	32.621
" 15...	18.265	19.842	21.133	35.133
Mar. 1..	19.230	20.732	20.065	34.581
" 15..	18.245	21.916	17.132	38.665
April 1..	15.854	19.515	22.415	34.581
" 15.	13.756	17.191	20.486	34.603

DETERMINATION OF ACIDITY IN FRUIT SPURS AND TWO-YEAR-OLD SEEDLINGS OF APPLE, EXPRESSED IN VALUES OF P_H.

Date	Spurs	Seedlings			
		1-Yr.-Old Stem	2-Yr.-Old Stem	Root	Leaf
	P_H	P_H	P_H	P_H	P_H
Nov. 1	3.6	3.2	4.4	6.4	3.0
" 15........	5.8	5.6	5.4	6.4	4.2
Dec. 1........	5.8	5.8	6.2	6.2	5.0
" 15........	6.0	6.0	6.2	6.2	...
Jan. 1........	6.2	5.6	6.2	7.0	
" 15........	6.2	6.2	6.2	7.0	...
Feb. 1........	6.0	6.0	6.8	7.0	...
" 15........	6.0	6.0	6.6	7.0	...
Mar. 1........	6.2	6.2	7.2	7.4	...
" 15........	7.0	7.0	7.2	7.4	...
April 1........	5.8	5.8	6.2	6.2	...
" 15........	6.0	6.2	6.6	6.2	...
May 1........	5.6	5.8	6.0	5.8	5.8
" 15........	5.6	5.6	5.6	5.8	5.4
June 1........	5.4	5.2	5.2	5.4	5.0
" 15........	5.2	5.2	5.0	5.4	4.8

N. B.—The data from July to October were not obtained.

NOTES ON THE LIFE HISTORY AND EARLY STAGES OF CORYTHUCHA CELTIDIS O. & D.

Harry B. Weiss,
New Brunswick, N. J.

This lace-bug was described by Osborn & Drake in 1916 in the Ohio State University Bulletin (Vol. XX, No. 35, Bulletin 8, Vol. II, No. 4, p. 227) from specimens taken at Columbus, Ohio, during September, 1903, on hackberry. Later these same authors in the Ohio Journal of Science (Vol. XIX, No. 7, May, 1919) recorded its occurrence in Kentucky, Tennessee and South Carolina. Gibson also treats this species in his paper on the genus *Corythucha* which appeared in 1918 (Tr. Am. Ent. Soc. XLIV, 69–104). Heretofore nothing has appeared on its life history and early stages and the following is presented as an addition to the knowledge of the biology of this species.

Adults were first noted in New Jersey at Riverton on June 1, depositing eggs on the lower surfaces of hackberry leaves. Later, on June 21, adults and eggs were collected at New Brunswick, N. J., and from this it appears that the insect is well distributed in this state. About two weeks are necessary for the eggs to hatch and the various stages each require from 2 to 4 days of very warm weather in which to complete their growth. Cool weather retards development. There are 5 nymphal stages and from 16 to 20 days are necessary for a newly hatched nymph to become an adult. Two generations occur in the latitude of New Brunswick, N. J. Newly hatched nymphs feed in colonies on the lower leaf surface but as they become older they scatter and feed more or less independently. Many colonies of nymphs are wiped out completely by spiders and predaceous bugs and their nymphs.

The eggs are inserted in the tissue of the lower leaf surface at right angles to the leaf, usually in the angle formed by the juncture of two veins. Only the basal end of the egg is inserted and each egg protrudes well beyond the leaf surface. They are laid close to one another and the clusters may contain anywhere from 4 to 18 eggs. The adults appear to wander over the tree considerably in the spring and as a result the egg clusters are scattered. Only rarely was it possible to find more than one or

two clusters on a single leaf. In many cases each cluster was found in the basal half of the leaf and the first nymphal feeding took place in this area.

Egg. Length, 0.55 mm. Greatest width, 0.17 mm. Subelliptical, one side more convex than the other; tapering most at basal end which is acute with rounded end, end slightly constricted where it is inserted in the leaf tissue; sides of apical half tapering slightly; extremity of apical end truncate with rim-like collar and projecting cone-shaped cap. Cap white, remainder of egg brownish to brownish black, shining.

First Stage Nymph. Length exclusive of spines, 0.61 mm. Greatest width exclusive of spines, 0.19 mm. Subelliptical, whitish or slightly brownish with a median dorsal, white area which includes part of the metathorax and the first two abdominal segments. Armature apparently similar to that of second stage nymph except that the only apparent tubercles are those on the head and the tubercular bases of the median abdominal spines. Remainder of armature appears to consist of simple spines with slightly tuberculate bases. Ventral surface, legs, antennæ whitish, most of spines white. Abdomen margined.

Second Stage Nymph. Length exclusive of spines, 0.78 mm. Greatest width exclusive of spines, 0.31 mm. Oval elongate; similar in color and armature to the third stage nymph. Armature more pronounced than in first stage.

Third Stage Nymph. Length exclusive of spines, 1.10 mm. Greatest width exclusive of spines, 0.40 mm. Oval; armature similar to that of fourth stage nymph except that the smaller spines on the margins of the thoracic lobes are absent and the lateral abdominal spines are single instead of double. Color and markings similar to those of fourth stage nymph. Color slightly darker than that of second stage nymph.

Fourth Stage Nymph. Length exclusive of spines 1.18 mm. Greatest width exclusive of spines 0.68 mm. More oval than third stage nymph. Color and markings similar to those of fifth stage nymph. Armature similar to that of fifth stage except that in addition, the second and third abdominal segments bear single lateral spines. Sides of prothorax produced laterally. Mesothoracic lobes reaching to second abdominal segment.

Fifth Stage Nymph. Length exclusive of spines, 1.75 mm. Greatest width exclusive of spines, 0.78 mm. Oval, dorsal surface dark brown, except for lateral half of prothoracic lobes and tubercles located on this surface, median dorsal portion of mesothorax, metathorax, and first abdominal segment and spines, posterior half of mesothoracic lobes and tubercles on this surface, the median portion of the eighth abdominal segment, the margins of abdominal segments seven and eight, the dorsal and lateral abdominal spines which are light. Antennæ, sparsely hairy, four-jointed, third joint about twice as long as the first two combined, fourth joint clubbed. Antennæ white except for clubs which are brownish. Eyes prominent consisting of numerous, reddish ommatidia. Head bears a pair of separated spines

between the eyes, posterior to this pair is a median tubercle bearing four spines, posterior to this tubercle and close to anterior edge of prothorax is a large pair of prominent tubercles each bearing five spines. Prothorax with a median dorsal elevation bearing a tubercle with two long spines and three shorter ones anterior to the long spines, behind this tubercle is a smaller median tubercle bearing a pair of diverging spines; posterior lateral margin of prothorax with a prominent tubercle bearing four spines; anterior to this tubercle on the margin are usually two large and three or four smaller spines (these spines vary in number and size); mesothorax with a pair of median separated tubercles each bearing three large spines; each mesothoracic lobe bears a prominent tubercle with four spines on lateral margin just posterior to middle; anterior to this tubercle are usually three large and two smaller marginal spines; centre of mesothoracic lobe slightly elevated; median separated spines on abdominal segments two, five, six, eight and nine; each posterior lateral margin of abdominal segments four, five, six, seven and eight bears a tubercle tipped with two long spines (sometimes a third short spine is present). All spines with tuberculate bases. All spines tipped with a short probably secreting hair. Abdomen strongly margined. Mesothoracic lobes reaching almost to fifth abdominal segment. Ventral surface brownish black except for the portion of the thorax between the legs and the first and second abdominal segments which are white. The lateral edges of abdominal segments six and seven are usually somewhat light. Legs whitish except for dark tarsi and claws. Legs sparsely hairy, hairs short and light brown in color. Rostrum extending to third thoracic segment, whitish except for brownish tip.

SCIENTIFIC RESULTS OF THE KATMAI EXPEDITIONS OF THE NATIONAL GEOGRAPHIC SOCIETY.

XIV. HEMIPTERA OF THE FAMILY MIRIDÆ.

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University of Minnesota.

Only thirteen species of Miridæ have heretofore been recorded from Alaska. Heidemann (1900) records ten species which were collected by the Harriman expedition. Of these, seven species were European forms which were known to extend their range into North America. Three species, *Mecomma gilvipes*, *Irbisia sericans*, and *Lygus approximatus* were originally described from Sitka by Stal (1858). *Orthocephalus saltator* (Hahn) was recorded from Alaska by Uhler (1886) but apparently in error for the writer has seen specimens of an *Irbisia* sp. taken in Alaska which bear the above name in Uhler's handwriting. No specimens of *Orthocephalus saltator* (Hahn), collected in North America, are to be found in the U. S. National Museum collection or the Uhler collection which is included there.

The present list enumerates eight species of which one has not before been recorded from the Nearctic region, two of which are new records for Alaska, and one new species. With the present list a total of sixteen named species of Miridæ are known to occur in Alaska.

Mecomma gilvipes (Stål).

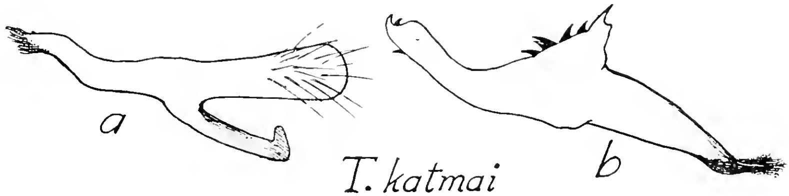
1858 *Leptomerocoris giloipes* Stal. Stett. Ent. Zeit., XIX, p. 187.
1883 *Mecomma gilvipes* Reuter, Hemip. Gymn. Eur., III, pp. 386, 555, Pl. 2, Fig. 6.
1886 *Mecomma ambulans* Uhler, Check List Hemip., p. 20.
1900 *Mecomma (Leptomerocoris) gilvipes* Heidemann, Proc. Wash. Acad. Sci., II, p. 504.
1909 *Mecomma gilvipes* Oshanin, Verz. Palæ. Hemip., I, p. 835.
1917 *Mecomma gilvipes* Van Duzee, Cat. Hemip., p. 398.

12 ♂ 2 ♀ Aug. 10–20, 1917, Katmai. This species was originally described from Sitka by Stal (1858). Heidemann (1900) records "numerous specimens" from five different localities in Alaska. The male of this species is very similar to the same sex of the European *Mecomma ambulans* (Fallén) which Uhler

(1886) recorded from British Columbia, but evidently in error. The female of *gilvipes* is easily distinguished by the short, yellowish translucent hemelytra (long-winged females are rare), while the male may be distinguished from *ambulans* with certainty only by the genital structures. Although Reuter (1883) records *Mecomma gilvipes* as occurring in Siberia, Oshanin (1909) states that the species has as yet been found only in the Nearctic region.

Tichorhinus katmai new species.

Fusco-brownish to blackish, median line on disk of pronotum pale; narrowly at base of embolium and corium, a small spot at the cuneal fracture, pale or translucent. Closely related to *marginatus* Uhler, differs chiefly in the structure of the right genital clasper, particularly in the shape of the apical half (Fig.).



Tichorhinus katmai n. sp. *a.* left genital clasper, lateral aspect.
b. right genital clasper, lateral aspect.

♂. Length 5 mm., width 1.6 mm. Pubescence and general form similar to *marginatus* Uhler. *Head:* width .85 mm., vertex .44 mm.; black, narrow tip of tylus and lower margin of bucculæ pale. Rostrum (length 1.45 mm.) barely attaining the hind margin of the intermediate coxæ, brownish to black, darker at the apex.

Antennæ: Black; segment I, length .44 mm.; II, 1.58 mm.; III, .94 mm.; IV, .74 mm.

Pronotum: length .71 mm., width at base 1.25 mm.; black, a pale vitta on the median line of the disk; scutellum black, transversely rugulose; sternum and pleura black, ostiole having a pale streak leading from the orifice.

Hemelytra: Brownish black to black; narrow base of corium and along the base of cubitus, pale translucent, apex of corium slightly translucent through the brownish black coloration; embolium brownish, translucent, paler toward the base; cuneus brownish black, pale translucent on the margin of the fracture. Membrane uniformly dark fuscous brown, the veins scarcely paler.

Legs: Fusco-brownish to black, in paler specimens the brownish may have a greenish tinge; tarsi black.

Venter: Brownish black to black; genital claspers distinctive of the species (Fig. 0).

♀. Length 4.6 mm., width 1.6 mm.; ovate, more robust than the male; membrane scarcely extending beyond the tip of the venter; more broadly pale on disk of pronotum and the base of the corium, also pale along the front margin of the eyes; antennæ dark brownish; legs brownish, slightly tinged with greenish; venter slightly pale at the base of the ovipositor.

Holotype: ♂ Aug. 10, 1917, Katmai, Alaska (Jas. S. Hine); Ohio State University Collection. Allotype: same data as the type. Paratypes: 3 ♂ 4 ♀ taken with the types.

Lygus pratensis oblineatus (Say).

1832 *Capsus oblineatus* Say, Heterop. Hemip. N. Amer., p. 21.
1857 *Capsus oblineatus* Say, Fitch reprint, Trans. N. Y. State Agr. Soc., XVII, p. 784.
1859 *Capsus oblineatus* Say, Le Conte edition. Compl. Writ., I, p. 340.
1917 *Lygus pratensis oblineatus* Knight, Bul. 391, N. Y. (Cornell) Agr. Exp. Sta., p. 562.

Five specimens of var. *oblineatus* (Say) were taken Aug. 16–20, Katmai. Heidemann (1900) records *pratensis* from Alaska, specimens which were probably similar to the above named variety.

Plesiocoris rugicollis (Fallén).

1829 *Phytocoris rugicollis* Fallén, Hemip. Suecia, p. 79.
1861 *Plesiocoris rugicollis* Fieber, Eur. Hemip., p. 272.
1896 *Plesiocoris rugicollis* Reuter, Hem. Gymn. Eur., V, p. 70.
1909 *Plesiocoris rugicollis* Oshanin, Verz. Palæ. Hemip., I, p. 733.

30 ♂ ♀ Aug. 2–15, 1917, Katmai; ♂ July, Savonoski, Naknek Lake. This species has not previously been known from North America. It is recorded from Siberia and Russia by Oshanin (1909) and is well known in northern Europe and Scandinavia. The writer has compared the present material with European specimens of *rugicollis* (Fallén), determined by Reuter, and finds them identical. Reuter (1896) records the species as occurring on *Salix* and rare on *Alnus*. The present record completes the link in the holarctic distribution of the species.

Irbisia sericans (Stal).

1858 *Leptomerocoris sericans* Stal, Stett. Ent. Zeit., XIX, p. 188.
1879 *Irbisa sericans* Reuter, Ofv. Finska Vet.-Soc. Forh., XXI, p. 58.
1896 *Irbisia sericans* Reuter, Hemip. Gymn. Eur., V, p. 12, Pl. 1, Fig. 4.
1900 *Irbisia (Leptomerocoris) sericans* Heidemann, Proc. Wash. Acad. Sci., II, p. 504.
1909 *Irbisia sericans* Oshanin, Verz. Palæ. Hemip., I, p. 760.
1915 *Irbisia sericans* Essig, Inj. Ben. Ins. Calif., edn. 2, p. 213.
1917 *Irbisia sericans* Van Duzee, Cat. Hemip., p. 325.

♂ ♀ July 2–Aug. 16, 1917, Katmai, Alaska. Prof. Hine reports this species as common on rye grass and a few other plants, it being the only Mirid that was taken in considerable numbers. The species was originally described by Stal (1858) from Sitka, and is now known to occur along the western coast from California to the Bering peninsula, thence extending its range to some of the islands bordering the Palæarctic region (Oshanin 1909). Essig (1915) reports the species as injurious to rye and oats in California.

Calocoris fulvomaculatus (De Geer).

1773 *Cimex fulvomaculatus* De Geer, Memoires, III, p. 294.
1861 *Calocoris fulvomaculatus* Fieber, Eur. Hemip., p. 253.
1875 *Calocoris (C.) fulvomaculatus* Reuter, Hemip. Gymn. Scand. Fenn., p. 49.
1886 (?) *Calocoris fulvomaculatus* Uhler, Check List Hemip., p. 18, "Br. Am."
1896 *Calocoris fulvomaculatus* Reuter, Hemip. Gymn. Eur., V, p. 184.
1907 (?) *Calocoris fulvomaculatus* Snow, Trans. Kans. Acad. Sci., XX, Pt. 2, p. 159.
1909 *Calocoris fulvo-maculatus* Oshanin, Verz. Palæ. Hemip., I, p. 691.
1917 *Calocoris fulvomaculatus* Van Duzee, Cat. Hemip., p. 329.

2 ♂ Aug. 10, 1917, Katmai. Uhler (1886) was the first writer to record this species from North America, merely indicating its occurrence and distribution as "Br. Am." So far as the writer can ascertain there is no specimen extant upon which this record was based. The next record for the species was based on material collected in the desert region of Arizona and published by Snow (1907). If the specimens upon which this record is based are the same as the true *fulvomaculatus* (De Geer) then the species has a remarkable distribution requiring adaptability, a condition not borne out by a known transitional distribution.

The writer has compared the present specimens with material from Finland, determined by Reuter, and finds that the coloration and male genital structures agree in every respect. *Calocoris fulvomaculatus* is recorded from Siberia by Oshanin (1909) and with the present specimens from Alaska the species would appear to have a holarctic distribution.

Teratocoris saundersi Douglas & Scott.

1869 *Teratocoris saundersi* D. & S. Ent. Mo. Mag., V, p. 260.
1875 *Teratocoris saundersi* Reuter, Hemip. Gymn. Scand. Fenn., p. 27.
1892 *Teratocoris saundersi* Saunders, Het. Brit. Isds., p. 226, Pl. 20, Fig. 8.
1895 *Teratocoris longicornis* Uhler, Hemip. Colo., p. 29.
1909 *Teratocoris saundersi* Reuter, Acta Soc. Sci. Fennicæ, XXXVI, No. 2, p. 7.
1917 *Teratocoris saundersi* Van Duzee, Cat. Hemip., p. 308.

11 ♂ ♀ July 31–Aug. 5, Savonoski, Naknek Lake. This species was described from Colorado by Uhler (1895) under the name *Teratocoris longicornis* where it was taken on *Carex* at Steamboat Springs by C. F. Baker. Reuter (1909) was the first to discover that *longicornis* Uhler was in reality identical with *Teratocoris saundersi* Douglas & Scott (1869) described from England. The species was later recorded from Scandinavia and Russia (Reuter 1875) and now with the present material coming from Alaska the species would appear to be holarctic in distribution.

Usually the males and dark females are characterized by having black along the median line of the head, pronotum and scutellum. Certain male specimens have the scutellum entirely black. The females may be entirely green but in such specimens the second antennal segment, apices of femora, base and apices of tibiæ are distinctly reddish.

Teratocoris herbaticus Uhler bears a close resemblance to *saundersi* D. & S. and after a study of a co-type specimen (♀) from Ungava Bay, Labrador, the writer wishes to remark on one or two distinguishing characters although Reuter (1909) has pointed out the chief differences between the species. In the female *herbaticus*, antennal segment I is shorter (length .43 mm., width .142 mm.) than in *saundersi* (length .57 mm., width .128 mm.). In a male specimen of *herbaticus* from Ft. Chimo, Labrador (L. M. Turner), the length of segment I (1 mm.) is shorter than in the male of *saundersi* (length 1.23 mm.), the thickness of the segment (.114 mm.) being the same in both specimens. In the male *herbaticus* there is in addition to the median discal stripe a prominent fuscous stripe on each side of the pronotum which extends back from the anterior angles half way to the basal margin of the disk, being sufficiently broad to cover the outer margin of the callus. The pubescence appears heavier and more distinct in *herbaticus* Uhler than in *saundersi* D. & S.

Miris ferrugatus Fallén.

1807 *Miris ferrugatus* Fallén, Monog. Cimic. Suec., p. 107.
1900 *Leptopterna ferrugata* Heidemann, Proc. Wash. Acad. Sci., II, p. 504.
1909 *Miris ferrugatus* Oshanin, Verz. Palæ. Hemip., I, p. 779.
1917 *Miris ferrugatus* Van Duzee, Cat. Hemip., p. 302.

13 ♂ 1 ♀ Aug. 10–20, 1917, Katmai. Heidemann records this species from Kadiak (July 20). It is known from Canada and is common in northern Europe and Siberia.

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ALGAL FOOD OF THE YOUNG GIZZARD SHAD.*

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Introduction.

During a survey† of the distribution and feeding habits of the Ohio fishes for the State Bureau of Fisheries, opportunity was afforded for the study of the algal food of the gizzard shad, *Dorosoma cepedianum* Le Sueur, collected at various places over the state. This paper is the result of an examination of some two hundred fishes from Buckeye, Indian, Loramie, St. Mary's and Chippewa Lakes, and the New Reservoir at Akron. While the major part of the discussion is devoted to the algal food of the gizzard shad, attention is called to the animal forms and other material found in the digestive tract, and to the economic importance of algæ as a part of the aquatic flora.

The writer desires to express his gratitude to those who so materially aided in the preparation of this paper: to Mr. A. C. Baxter, Chief of the State Bureau of Fisheries, for kindly permitting the use of the gizzard shad, collected during the survey, for a botanical study; to Professor R. C. Osburn, for suggesting examination of the stomachic and intestinal content of the fish; and especially to Professor E. N. Transeau, who first introduced me to the study of algæ in the summer of 1912, for the loan of algological literature and for helpful criticisms on species determination and identification.

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*Papers from the Department of Botany, Ohio State University, No. 123.

†This survey covered a period of three months (June 15 to Sept. 15, 1920) and was under the direction of Professor R. C. Osburn, Ohio State University, assisted by Professor C. L. Turner, Beloit College, Mr. E. L. Wickliff, Mr. W. C. Kraatz, and the writer, Ohio State University.

Methods of Collection and Study.

The fishes were caught in a large fine-meshed seine and placed immediately in a ten per cent solution of formalin, thus preserving the stomachic and intestinal content and preventing further digestive action. Collections were made at nearly all hours of the day. An examination of the content of the digestive tract was made with a compound microscope, the oil immersion being necessary in many cases for a final determination of species. The technique of the work is very simple. A longitudinal slit, made along the ventral side of the fish, exposes the stomach and intestine, a small portion of which can then be pinched off and a microscopic mount made in the usual way. Adult fishes are not included in this discussion, examination being limited to specimens 1.5 to 7.5 centimeters in length—measured from the point of the snout to the base of the caudal fin.

Food and Feeding Habits—General.

Since the excellent work of Forbes, nearly forty years ago, on the freshwater fishes of the United States, very little study has been made upon the nature of the food of the gizzard shad. According to Forbes (3), the shad is a "mud lover *par excellence*"; it swallows "large quantities of fine mud containing about twenty per cent of minutely divided vegetable debris"; and it consumes, when young, food that is approximately ninety per cent microscopic animal organisms and the rest microscopic plants. From data at hand it appears that these statements require considerable modification when applied to young fish within the limits of this study.

Mud may form as much as thirty per cent of the contents of the digestive tract, or it may be entirely lacking; in fact, in those fishes taken from St. Mary's Lake it was quite impossible to detect even the smallest quantity. A small portion of the contents is unrecognizable plant debris. It appears that the mud is merely incidental—so much unavoidable non-nutrient material that goes in with the real food. No consideration is given, therefore, to its varying amount in the digestive tract.

The number of microscopic algal forms found in the stomach and intestine of the gizzard shad is markedly large. If one can conceive of all the different plankton forms of a given lake

as being concentrated in one gizzard shad, he will get some idea of the vast number of individuals present at one time in the fish. In fact, the gizzard shad is about the most wonderful tow net that one could desire to get an estimate of the kinds and proportionate numbers of microscopic algæ present in a body of water. In a single fish taken at Buckeye Lake on July 1, fifty species and varieties of algæ were found; from all the specimens examined to date, one hundred and forty different forms are recorded.

The presence of such masses of microscopic material in the digestive tract of the gizzard shad is accounted for in part when the feeding apparatus of the fish is examined. The very numerous fine gill rakers on the gill arches oppose the escape through the gill slits of very small objects. Thus, like a very fine sieve, these allow the water to pass out through the gill slits as the fish swims along with its mouth open, while the minute organisms are retained and pass into its alimentary canal.

Animal vs. Plant Food.

When a comparison of the number of animal and plant forms is made (See Table I below), it is noted that plants make up from seventy to one hundred per cent of the food material of the gizzard shad; animal forms, from zero to thirty per cent, depending upon the particular fish and locality. It should be further noted that even the animal organisms, fed upon by the gizzard shad, depend directly for their food supply on the microscopic algæ. The animal forms include copepods, cladocerans, rotifers, and protozoa.

TABLE I.

Maximum and minimum percentages of plant and animal food in gizzard shad, based on examination of fish collected June 15—September 15.

Kind of food	Buckeye L.	Indian L.	Loramie L.	St. Marys L.	Chippewa L.	New Reservoir
Animal	0–30%	3–20%	2–15%	0–10%	1–10%	5–15%
Plant	70–100%	80–97%	85–98%	90–100%	90–99%	85–95%

The majority of the algal forms belong in the order *Protococcales*. For convenience of comparison each individual identified is placed in one of seven groups: *Myxophyceæ*, *Peridineæ*, *Euglenidæ*, *Bacillariæ*, *Desmidiaceæ*, *Protococcales*, and the filamentous algæ.

In the following table is given the relative importance of each group for the six localities named above. The first column under each group represents the total number of algal species and varieties found in the fishes, and the second column gives the total percentage content of the group for the particular locality. The percentages are approximations based on the total number of individuals present, not on the number of species and varieties, belonging in each group.

TABLE II.

Number of species in, and percentage importance of, algal groups. The first column gives number of species and varieties identified for the group; the second, the total percentages of food content represented by these species.

Name of Lake	Myxophyceæ		Euglenidæ		Peridineæ		Bacillariæ		Desmidiaceæ		Protococcales		Filamentous algæ	
Buckeye..	5	2%	4	6%	2	5%	13	10%	10	3%	62	70%	3	4%
Indian....	0	0	4	6%	1	4%	4	6%	4	4%	25	80%	0	0
Loramie..	1	1%	3	2%	1	2%	4	8%	3	2%	22	80%	3	5%
St. Mary's	2	1%	1	1%	1	1%	2	1%	7	5%	31	90%	2	1%
Chippewa	3	3%	3	2%	1	1%	7	10%	5	5%	19	77%	1	2%
New Reservoir	1	10%	2	3%	2	2%	3	5%	3	2%	31	76%	1	2%

The filamentous algæ were always present in small quantities, if found at all, and no single plant was observed longer than 300μ. It is easily seen how short, detached filaments could enter the fish with the water of respiration. It was not observed that the gizzard shad secured its food in any other way. No material was found wadded up, either in the stomach or the intestine, as is so often true among the game fishes. In one shad the remains of some epidermal and palisade cells of a leaf were found, but these may be considered as purely accidental, ingested in the usual manner.

It will be noted from Table I that the percentages of plant food present in the digestive tract are very high and relatively constant. Throughout the period during which the gizzard shad is attaining a length of 7.5 centimeters, there is very little change of diet. Nor does the diet appear to change materially with greater age. An examination of two gizzard shad twenty centimeters in length showed practically the same proportion of microscopic algæ found in the younger fishes, the only variation being a slightly larger amount of unrecognizable debris.

Algal Forms.

In Table III below is given a list of the 140 species and varieties of algæ found in an identifiable condition in the digestive tract of the gizzard shad. Their abundance in each locality is noted by the letter x. x= rare, or occasional; xx=common; and xxx=abundant.

TABLE III.

Algal Species and their Relative Abundance.

Algal Species or Variety	Buckeye Lake	Indian Lake	Loramie Lake	St. Mary's Lake	Chippewa Lake	New Reservoir
Merismopedia glauca (Ehr.) Naeg	x		xx	x	x	
“ elegans A. Br.					x	
“ tenuissima Lemm	x			x	x	
Coelosphaerium kutzingianum Naeg.	x					
Microcystis marginata (Menegh.) Kuetz.	x					xxx
Tetrapedia Reinschiana Arch	x					
Spirulina major Kuetz					x	
Euglena spirogyra Ehr	xx	xx	x	x	x	x
“ oxyuris Schm	xx	xx	x			
Phacus longicauda (Ehr.) Duj	x	xxx			x	x
“ pleuronectes (O. F. M.) Duj.	x	x	x		x	
Peridinium aciculiferum Lemm	xxx	xx	xx	xx	x	x
Ceratium hirundinella O. F. M.	x					x
Melosira varians Ag.	x	x	x	x	x	x
“ roseana Rab. var. epidendros (Ehr.) Grun					x	
“ crenulata (Ehr.) Kuetz	x				x	
“ distans (Ehr.) Kuetz	xxx	xxx	xx		x	x
“ granulata (Ehr.) Ralfs.					x	
Cymbella ventricosa Kuetz	x					
“ cymbiformis (Kuetz.) Breb.	x					
“ mexicana (Ehr.) A. S.	x					
“ affinis Kuetz	x					
Cyclotella striata (Kuetz.) Grun					x	
“ comta (Ehr.) Kuetz					x	
Asterionella gracillima (Hantz.) Heib.	x					
Navicula cryptocephala Kuetz		x				
“ salinarum Grun	x	x	x	x		x
Synedra pulchella (Ralfs) Kuetz.	x		x			
Meridion circulare (Grev.) Ag.	x					
Cocconeis placentula Ehr.	x					
Caloneis trinodis (Lewis) Boyer	x					
Arthrodesmus triangularis Lag.	x			xx	x	
“ “ Lag. var. subtriangularis (Borge) W. & G. S. West forma triquetra G. S. West	x	x	x	x		x
Staurastrum cyclacanthum W. & G. S. West	x	x		x		x
“ leptocladeum Nordst. var. elegans G. S. West				x		
Closterium pronum Breb	x					
“ acerosum (Schr.) Ehr.	x					x
“ Ehrenbergii Menegh	x					
“ parvulum Naeg				x		
Cosmarium Regnellii Wolle	x					
“ laeve Rab		xx	x	x	x	
“ tenue Arch				x	x	
“ margaritiferum (Turp.) Menegh					x	
“ undulatum Corda					x	
“ radiosum Wolle	x					
“ subcostatum Nordst		x				
“ subnotabile Wille			x			
Pleurotaenium Trabecula (Ehr.) Naeg.	x					
Euastrum elegans (Breb.) Kuetz	x					x
Gonium pectorale Muller					x	
Pandorina morum (Mull.) Bory	x				x	
Eudorlna elegans Ehr.	x					
Pleodorina illinoiensis Kofoid	x					

TABLE III—Continued.

Algal Species or Variety	Buckeye Lake	Indian Lake	Loramie Lake	St. Mary's Lake	Chippewa Lake	New Reservoir
Eurodinella wallichii (Turn.) Lemm.	x				xxx	
Volvox aureus Ehr.	x					
Gloeocystis gigas (Kuetz.) Lag.	x					
Chlorella pachyderma Printz	xx				x	
Oocystis Borgei Snow	x	xx		x		x
" pusilla Hansg.				x		
" elliptica W. West				x		
Micractinium radiatum (Chod.) Wille	x			x		
Lagerheimia genevensis Chod. var. subglobosum (Lemm.) Chod.	x					
Lagerheimia ciliata (Lag.) Chod. var. amphitricha (Lag.) Chod.	x	x			x	
Chodatella citriformis Snow				xx	x	x
Franceia ovalis (France) Lemm.				x		
Tetraedron muticum (A. Br.) Hansg.	x	x	x	x	x	x
" minimum (A. Br.) Hansg.	x					
" regulare Kuetz.	x	x				
" " torsum Turn.	x				x	
" " longispinum Reins.	x					
" enorme (Ralfs) Hansg.	x					
" " aequiseetum Reins.	x					
" hastatum (Rab.) Hansg. palatinum (Schm.) Lemm.	x	x		x		
" trigonum (Naeg.) Hansg. var. gracile Reinsch	x		x			x
Ankistrodesmus falcatus (Corda) Ralfs.				x		
" " mirabilis G.S.W.		x				
Selenastrum gracile Reinsch						x
" acuminatum Lag.	x	x	x	x		x
Actinastrum Hantzschii Lag.				x		
Kirchneriella lunaris (Kirch.) Moeb.				x	x	x
" obesa (W. West) Schmid.	x		x	x	x	
" " major (Ber.) G. M. Smith	x	x	x			
" subsolitaria G. S. West				x		
Scenedesmus obliquus (Turp.) Kuetz.	x					
" dimorphus (Turp.) Kuetz.	x					
" acuminatus (Lag.) Chod.			xx	x		x
" bijuga (Turp.) Lag.	xx	x	x	x	x	x
" " flexuosus (Lemm.) Coll.	x	xx		x		
" " irregularis (Wille) G. M. Smith	x					
" arcuatus Lemm.	x					
" " platydisca G.M.S.	x					
" denticulatus Lag.	x	x	x	x		
" carinatus (Lemm.) Chod.				x		x
" abundans (Kirch.) Chod.			x	x		
" " spicatus (W. & G.S.West) G.M.Smith	x					
" longus Meyen		x				
" " dispar (Breb.) G. M. S.	x					
" quadricauda (Turp.) Breb	xx	xxx	xxx	xx	x	xx
" " longispina (Chod.) G. M. S.	x					x
" quadricauda Westii G.M.S.	x					
" " parvus G.M.S.	x		x			
" opoliense Richt.	x	x	x	x		x
" armatus (Chod.) G. M. S.	x			x		
Crucigenia rectangularis (A. Br.) Gay	xx	x	x		x	x
" quadrata Morren	x					
" irregularis Wille			x			x
" Tetrapedia (Kir.) W. & G. S. W.	x		x		x	x
" emarginata (W. & G. S. W.) Schm.	x					
Tetrastrum tetracanthum (G. S. W.) Brunn.		x		xxx		
Coleastrum microsporum Naeg.	x	x	x	x	x	x
" sphaericum Naeg.	x	xx	x	x		x
" cambricum Archer		x	x		x	
" reticulatum (Dang.) Senn.						x
" morus W. & G. S. West. var. capense Fritsch						xxx

TABLE III—Continued.

Algal Species or Variety	Buckeye Lake	Indian Lake	Loramie Lake	St. Mary's Lake	Chippewa Lake	New Reservoir
Pediastrum simplex Ralfs	xxx	xx	x	xxx	x	xx
" " radians Lemm	xx	....	....	xx	....	x
" clathratum (Schr.) Lemm	xxx	x	....	x	....	x
" " microsporum Lemm	x	....	....	....	....	....
" " punctatum Lemm	x	....	....	....	....	....
" clathratum duodennarium Bailey	x	....	....	....	....	x
" duplex Meyen	xxx	xx	x	xx	x	xx
" " reticulatum Lager	x	x	....	....	....	x
" " subgranulatum Racib	....	....	....	....	....	....
" Boryanum (Turp.) Menegh	xxx	xx	x	xx	x	xx
" " perforatum Racib	x	....	....	....	....	....
" " brevicorne A.Br.	x	....	....	....	....	....
" " longicorne Reins.	x	....	....	....	....	....
" " granulatum (Kg.) A. Br.	x	....	....	....	....	....
" " forcipatum Racib.	x	....	....	....	....	....
" tetras (Ehr.) Ralfs	xx	....	....	x	....	x
" " excisum Rab	....	....	....	x	....	x
" biradiatum Meyen	x	....	....	....	....	x
" " emarginatum A. Br.	....	....	....	....	....	x
Ulothrix oscillarina Kuetz	....	....	....	x	....	....
Spirogyra Weberi Kuetz	x	....	....	....	....	....
Oedogonium crassiusculum Wittr. var. idioandrosporum Nordst & Wittr	....	....	x	....	....	....
Tribonema bombycinum (Ag.) Derb. & Sol	x	....	....	....	....	....
" " tenuis Hazen	x	....	....	....	....	....

Notes on Some Algal Forms.

Peridinium aciculiferum Lemm.

A number of stages in the life history of this form were observed, besides the ordinary vegetative cells: thick walled resting spores, thin walled resting spores, and the encysted state.

Pleodorina illinoiensis Kofoid.

The presence of somatic cells in the anterior region of the coenobium was observed in most of the specimens examined. In some cases, however, no differentiation could be noted in the cells, and it was not always possible to separate this alga from *Eudorina elegans*.

Eurodinella wallichii (Turner) Lemm.

The definite arrangement of the cells as described by Fritsch[2] seems to warrant the retention of this alga as a distinct genus of the *Volvocaceæ*.

Chlorella pachyderma Printz.

Previously reported from Asia.

Kirchneriella obesa (W. West) Schmidle var. **major** (Bernard), G. M. Smith.

Although but a few specimens of this alga were noted, it is without doubt the variety figured by Smith.[9]

Scenedesmus acuminatus (Lemm.) Chodat.

Very common in the digestive tract of the gizzard shad. The dimensions of the cells, the distance between the apices, and the general shape of the coenobium unquestionably place it with the typical form.

In the identification of the species of *Scenedesmus*, the classification of G. M. Smith[7] has been followed throughout.

Coelastrum morus W. & G. S. West, var. **capense** Fritsch.

Previously described from Africa. The American material has cells 10–15 microns in diameter; the emarginate-truncate warts 1–3 microns. Otherwise like the description given by Fritsch.[2]

Pediastrum clathratum (Schroeter) Lemm.

In an examination of thousands of specimens of *Pediastrum* with single spines, the constancy of small intercellular spaces between the cells seems sufficient for the retention of this alga as a distinct species. I have listed four varieties of this species in Table III, based on the nature of the intercellular spaces.

It was possible to find practically all graduations between *P. simplex* and *P. Sturmii* Reinsch. This would seem to bear out the statement of Harper[4] that the *Sturmii* forms are "merely colonies of *P. simplex* approaching the reproductive stage." Similar gradations were also noted between *P. clathratum* and *P. ovatum* (Ehr.) A. Br.

Ulothrix oscillarina Kuetz.

Only a few short filaments of this alga were found, but the dimensions of the cells and shape of the chloroplasts agree so closely with the description given by Fritsch[2] that there seems little doubt for referring the material to this species.

Spirogyra Weberi Kuetz.

No fruiting material was found in the gizzard shad. But the presence of fruiting cells in material collected at Buckeye

Lake at the same time the fish were taken helped to identify the sterile cells.

Oedogonium crassiusculum Wittr. var. **idioandrosporum** Nordst. & Wittr.

Only vegetative cells were present in the fishes, but fruiting material collected at Lake Loramie along with the shad furnished the means for identification. At least two other species of *Oedogonium* were observed, but identification was not possible.

Algæ and Game Fishes.

That algæ furnish the ultimate source of food for practically all aquatic animal life, no one doubts. But the importance of algæ to our game fishes, and hence to the supply of fish for the food of man, is not so generally recognized, chiefly because the relation is obscured by ignorance of the intermediate steps. The route from algæ to the game fishes is usually a long one, as might be represented by the following: tiny crustaceans living on algæ are eaten by larger animals; these in turn by small fishes; and finally the larger fishes are reached. Through the gizzard shad, however, the cycle is much more direct.

Not more than a decade or two ago most icthiologists were agreed that the gizzard shad was a beautiful but nevertheless a worthless fish. That it is beautiful no one will dispute, but it is decidedly not worthless. With its silvery white sides and its graceful rapid dashes through the water near the surface, it makes a very attractive fish. While it is not a game fish and at the present time furnishes very little food for man, it holds a very important place in the food supply of a number of our game fishes, notably the small and large mouth bass, the crappie, and the white bass. The young gizzard shad furnish excellent food for these fishes, which experience no difficulty in disposing of the too numerous bones. As noted above, the shad is almost wholly a vegetarian, and thrives on algæ so minute that often 10,000 of them laid side by side would not reach an inch. Algæ of this kind form a very important part of the flora of most unpolluted bodies of water and are absolutely essential for the gizzard shad. None of the game fishes seem to be able to utilize this great source of food. Thus the gizzard shad holds a rather unique position in that it furnishes a direct

connection between the game fishes and the ultimate source of their food supply—the microscopic algæ.

Summary.

1. The food of the gizzard shad consists, in the main, of microscopic algæ, with a small variable percentage of microscopic animal organisms.

2. A total number of one hundred and forty species and varieties of algæ were found in an identifiable condition in the digestive tracts of the fishes examined. These may be conveniently grouped into the following: *Myxophyceæ*, *Euglenidæ*, *Peridineæ*, *Bacillariæ*, *Desmidiaceæ*, *Protococcales*, and the filamentous algæ.

3. Microscopic algæ furnish the ultimate source of food for practically all aquatic animals.

4. The gizzard shad furnishes excellent food for most of our game fishes, but is itself wholly a vegetarian. Thus the gizzard shad holds an almost unique position as a direct connection between microscopic algæ and the game fishes.

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CONCERNING "LARVAL" COLONIES OF PECTINATELLA.

Stephen R. Williams,
Miami University.

During several summer sessions of the Lake Laboratory of the Ohio State University, as occasion offered, the sexual reproduction of the Bryzoan Pectinatella has been kept under observation.

As is well known, Pectinatella grows in large submerged masses attached to any artificial support. The thickened cuticle which makes the skeleton of Bryozoans is in this case a gelatinous mass with the polyps distributed in irregular patterns over the surface. When the colony reproduces sexually the fertilized egg is retained for a time in the superficial portions of the gelatin. There it develops what Parker and Haswell, Vol. I, p. 325, call "a ciliated hollow cyst from which the colony is derived by gemmation."

The individual polyps connected with this cyst are not especially embryonic and can hardly be distinguished from polyps dissected out from an adult colony. According to the Cambridge Natural History, Vol. II, p. 512, "The peculiarity of the Phylactolaematous larva may be explained by assuming that it becomes a zooecium while it is still free-swimming. Thus the larva of Plumatella develops one or sometimes two polypides which actually reach maturity before fixation takes place. That of Cristatella develops from two to twenty polypides or polypide buds at the corresponding period, and it is in fact a young colony while still free-swimming."

In Pectinatella the so-called larval colony is freed from the adult gelatin after an undetermined stay and may be obtained in small numbers at certain times by sweeping around the adult with a dip-net. Unfavorable conditions hasten the giving off of these forms. Of two adults on the same stick, one partly out of water due to a S. W. wind was giving off many more larval colonies than the other. By bringing the adult into the laboratory, the stimulus of the changed environment results in the freeing of hundreds of these colonies.

The earliest date at which the free colonies have been taken in the open water around the adults is July first in

Terwilliger's Pond, South Bass Island. Towards the last of July almost every Pectinatella is producing both statoblasts and these colonies in large numbers. The non-sexual statoblasts seem to be produced in numbers later in the season than the sexual colonies. I could not decide whether there is a natural aperture for emergence or whether they go through breaks in the envelope, but the latter seem the most likely. (Fig. 1).

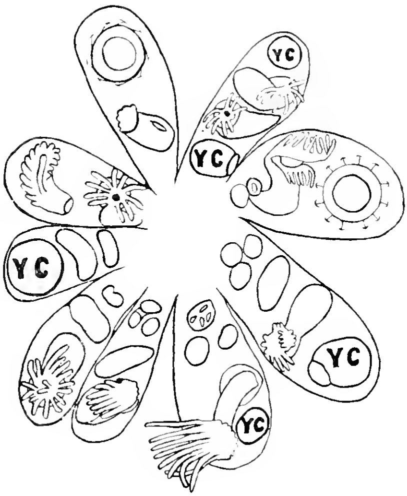

FIG. 1

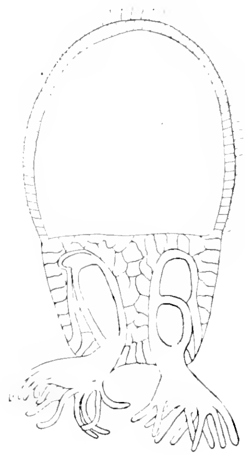

FIG. 2

Figure 1. Pectinatella, adult. One cluster of branches showing larval colonies and two statoblasts. × 25.

Figure 2. Diagrammatic sketch of free swimming colony. × 100.

As the larval colony is freed from the parent it is a ciliated float or bladder with a number of polyps below. There may be from one to five polyps, the usual number being four. As the colonies swim upwards by ciliary action, then sink, swim, sink, they have much the appearance of microscopic balloons.

They are from two to five millimeters long and about half as wide as they move in the water. The range of variation in length is great because the polyps of the cyst may be retracted into the gelatinous mass at the base of the float or may be extended downward with outspread tentacles swinging for food. The cyst also may contract.

The animals are, as one would expect, somewhat negative to light, but it is difficult to get precise records of the moving forms. One can be exact with the colonies as they affix themselves. When attaching to the side of a battery jar covered with pasteboard which had a rectangular hole two inches by one inch cut on the window side of the jar, out of thirty-six larval colonies, thirty attached on the half of the jar away from the window and six on the half of the jar toward the window.

The colonies were distributed vertically in a definite way also, eight only being in the lower three inches of the water and the rest in the upper four inches, more than half of the thirty-six colonies being located between one inch and three inches below the surface of the water.

FIG. 3

FIG. 4

FIG. 5

Figure 3. Pectinatella. Sketch of camera drawing of recently set colony. × 100.
Figure 4. Four-polyp colony starved; fully differentiated; yolk all gone. × 25.
Figure 5. Last polyp of a starved colony, was letting loose from wall. Mth.= mouth. An.=anus. At.=point of attachment. × 100.

When no light at all was admitted to the battery jar, out of thirty-four colonies, twenty-three attached in the lower three inches of water and eleven in the upper two inches.

These colonies are also quite sensitive to foul water. At 11:30 A. M., one day an adult colony, which nearly filled a battery jar, was brought in. At 1:30 the adult was removed. The next morning the water in the jar was foul, one hundred and fifty colonies were in the first inch, eight in each of the next two inches and seven scattered in the lower four inches of water. In spite of the crowding to the top the attachment of the one hundred and fifty colonies was chiefly on the side of the jar away from the window, so the need for oxygen did not inhibit the customary light reaction.

The process of attaching is a very rapid one and has been observed a number of times. A specimen will be swimming and when possible striking the top of its float against some solid body. The side of the jar can be used in default of anything which can be struck more directly from beneath. Those observed were seen to fix the apex of the float to the glass, to shrink to as little as one-fourth of their swimming length and show in the center, between the polyps, a mass of orange-colored yolk. (Fig. 3). The epithelium of the place of attachment is sticky, so if the colony is scraped off at once it will stick to the knife. There are, in my opinion, as many sticky points at the top of the float as there are polyps in the colony, since attachment can be made a little off from the exact center of the float.

The larger portion of the float, in addition to being ciliated on the outside, possesses delicate bands of tissue in its wall which, when the colony attaches must serve to compress the contents of the cyst and to bring the yolk into the central region between the polyps. The liquid material which is contained in the cyst as it swims, shows very little of the orange color which characterizes the yolk of the attached colony. It is possible that this liquid content is a salty solution, in which case vitellin would be dissolved in it. If then, when the colony attached, the salt was taken up by the cells of the organisms, the dissolved yolk material would at once appear, as yolk is insoluble in water. There is, however, in preserved free colonies some solid yolk, as has been demonstrated by sectioning, so that the fact that none is visible may be due to the central position it holds. The rapid contraction of the walls of the cyst may force the yolk into the center between the polyps where it is most conspicuous. (Fig. 2).

The colonies, after attachment to the side of the jar, find no adequate supply of food. Since they starve to death in spite of the fact that the alimentary canals of many of them showed that they were filled with one-celled algae, I assume Pectinatella uses animal food. For the colonies exist and differentiate only as long as there is a yolk supply. (Fig. 4). Some of them, at least, then retrogress in an interesting way. Instead of all the polyps starving at once they are reduced successively from four, or the normal number, to three, to two, to one. The latest persisting polyp appears normal and healthy until

all of the tissue of the other polyps of the colony has disappeared. (Fig. 5). Then the mucus attachment elongates, the animal drops off and dies. This change took place in the specimens under observation in from three to four days after the time of attaching. Here I transfer a few sentences from my notes. Larval colonies of Pectinatella swept from around adults July 3, all set July 4. Three colonies at the surface film, one just at the middle of jar, four near the bottom. July 5, one of the lower colonies gone. Two of the others have but two colonies. Appear filled with algæ. July 6, another gone. Two colonies reduced to one polyp each. One has slipped on the glass diagonally downward half an inch. July 7, out of the eight colonies set on July 4, three are entirely gone, two have one polyp apiece, three appear normal. July 8, one only—near the bottom of jar. Planaria (Stenostomun) have been seen to eat the polyps of Plumatella and I assume they may be responsible for some of this disappearance.*

If we assume that the larval colony develops from a single fertilized egg, there is here a definite reversal of the growth processes as an adaptation to external conditions. A slightly similar type of reversal of growth occurs normally when the tail of the transforming tadpole is absorbed. Possibly the analogy is closer in the case of human disease when the fat and muscle of the body is depleted, while the nervous system still retains the large percentage of its tissue. The case in point, however, is the resorption of an independent individual, practically cut off from the rest of the colony.

In this particular case, if the explanation given is the true one, we find a device for prolonging the life of Pectinatella in the face of starvation, which should be of importance in the distribution of the species.

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*It may even be that this gradual disappearance of the polyps of a colony is due to their being eaten, one at a time, by some carnivorous creature and to this cause only. The regularity of reduction, however, would be in favor of the hypothesis offered above.

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1920.*

John H. Schaffner,
Ohio State University.

In the following list are included a number of species new to the state, a number which have been in the catalog but not represented by specimens, and a considerable number which extend the known range of their distribution in the state. Because of its peculiar geographic position, Ohio has an unusual number of species which have their limits within its boundaries. It is hoped that the knowledge of the indigenous species will be rapidly increased so that it will be possible to publish accurate distribution maps of these plants.

Plant geography will probably be of much greater economic importance in the future than it has in the past and accurate data of the present distribution of plants will be of much value to the systematist, ecologist, agriculturist, and the plant geographer who wishes to interpret the present species distribution in relation to past migrations, especially, as these were affected by the glacial period. For such work state catalogs giving distribution notes by counties are very useful, for it thus becomes easy to trace out limits on the ordinary maps.

69. **Pinus rigida** Mill. Pitch Pine. Near Marietta, Washington County. W. V. Balduf.

70. **Pinus virginiana** Mill. Scrub Pine. Winterset, Guernsey County. T. L. Guyton. Near Marietta, Washington County. W. V. Balduf.

71. **Pinus echinata** Mill. Shortleaf Pine. Jackson Township, Pike County, near the Ross County line. "Confined to northeastern section, occupying ridges capped with heavy sandstone." Forest W. Dean. Jefferson Township, Scioto County, three miles south of the Pike County line. Forest W. Dean. Near Marietta, Washington County. W. V. Balduf.

*Papers from the Department of Botany, Ohio State University. No. 125.

76. **Taxus canadensis** Marsh. American Yew. Five miles east of Somerton, Belmont County. Emma E. Laughlin.

143. **Cyperus flavescens** L. Yellow Cyperus. Hillsboro, Highland County. Katie M. Roads.

340. **Eragrostis capillaris** (L.) Nees. Capillary Love-grass. Hillsboro, Highland County. Katie M. Roads.

385. **Sporobolus neglectus** Nash. Small Rush-grass. God's Garden, New Market Township, Highland County. Katie M. Roads.

403. **Muhlenbergia tenuiflora** (Willd.) B. S. P. Margaretta Ridge, Erie County. E. L. Moseley. Specimen in U. S. Herb. Reported by B. F. Bush.

461. Change name to **Cenchrus pauciflorus** Benth. As the species are now segregated, C. tribuloides L. is confined to the Atlantic coast.

466. **Holcus halapense** L. Johnson-grass. Near Hillsboro, Highland County. Katie M. Roads.

470. **Andropogon virginicus** L. Virginia Beard-grass. New Market Township, Highland County. Katie M. Roads.

472. **Coix lacryma-jobi** L. Job's-tears. Persistent after cultivation, Hillsboro, Highland County. Katie M. Roads.

482. **Allium tricoccum** Ait. Wild Leek. Put-in-Bay Island, Ottawa County. M. E. Stickney.

483. **Allium vineale** L. Field Garlic. Near Bridgeville, Muskingum County, and near Cambridge, Guernsey County. Mrs. Bayard Taylor.

499. **Chamaelirium luteum** (L.) Gr. Chamælirium. On black sandy loam. Mesophytic woods, Hazelwood, Hamilton County. Reported by E. Lucy Braun.

522. **Smilax echirrhata** (Engel.) Wats. Upright Smilax. Prairie Township, Franklin County. John H. Schaffner.

532.1. **Commelina communis** L. Asiatic Day-flower. A common weed in Columbus, Franklin County. John H. Schaffner. Specimens also from Lake, Cuyahoga, Montgomery and Clermont Counties.

533. **Commelina virginica** L. Read—No specimens in the herbarium. All so listed are Commelina communis L.

579a. **Blephariglottis psycodes grandiflora** (Bigel.). Orwell, Ashtabula County. Coll. E. E. Bogue, July 29, 1889.

629. **Aquilegia vulgaris** L. European Columbine. Escaped from cultivation, Columbus, Franklin County. John H. Schaffner.

633.1. **Anemone japonica** Sieb. & Zucc. Japanese Anemone. Escaped from cultivation and very persistent. Hillsboro, Highland County. Katie M. Roads.

639.1. **Atragene americana** Sims. Atragene. On Scioto River exposed limestone cliff. Delaware County, north of Franklin County line. Growing with Thuja occidentalis L. John H. Schaffner, Freda Detmers and Lillian E. Humphrey.

703. **Thlaspi arvense** L. Field Penny-cress. West Jefferson, Madison County. Mrs. Bayard Taylor.

708. **Cheirinia cheiranthoides** (L.) Link. Wormseed Mustard. Barnesville, Belmont County. Emma E. Laughlin.

714. **Conringia orientalis** (L.) Dum. Hare's-ear Mustard. Ironton, Lawrence County. Lillian E. Humphrey. Also Barnesville, Belmont County. Emma E. Laughlin

733. **Cardamine rotundifolia** Mx. Roundleaf Bitter-cress. Ironton, Lawrence County. Lillian E. Humphrey.

739. **Dentaria diphylla** Mx. Two-leaf Toothwort. Ironton, Lawrence County. Lillian E. Humphrey.

741. **Dentaria heterophylla** Nutt. Slender Toothwort. Ironton, Lawrence County. Lillian E. Humphrey.

754. **Polonisia graveolens** Raf. Clammy-weed. Put-in-Bay Island, Ottawa County. M. E. Stickney.

756. **Reseda luteola** L. Dyer's Mignonette. Persistent after cultivation. Hillsboro, Highland County. Katie M. Roads.

771.1. **Tribulus terrestris** L. Land Caltrop. Zygophyllaceæ. Caltrop Family. Waifs growing along railroad east of Barnesville, Belmont County. Emma E. Laughlin.

823. **Althæa officinalis** L. Marsh-mallow. Along ditch, near Delaware, Delaware County. Mrs. Bayard Taylor.

827. **Napæa dioica** L. Glade Mallow. Spring Valley Township, Greene County. Mrs. Bayard Taylor.

878. **Viola sororia** Willd. Woolly Blue Violet. Hillsboro, Highland County. Katie M. Roads.

933. **Allionia nyctaginea** Mx. Heartleaf Umbrella-wort. Columbus, Franklin County. John H. Schaffner.

1008. **Potentilla argentea** L. Silvery Cinquefoil. Dublin, Franklin County. John H. Schaffner.

1017. **Waldsteinia fragarioides** (Mx.) Tratt. Dry Strawberry. Five miles east of Somerton, Belmont Co. Emma E. Laughlin.

1034. **Filipendula rubra** (Hill.) Rob. Queen-of-the-prairie. Near Harmony, Clarke County. Mrs. Bayard Taylor.

1054. **Pyrus communis** L. Pear. Growing wild at margin of a wood along road near Lancaster, Fairfield County. John H. Schaffner.

1104. **Baptisia leucantha** T. & G. Large White Wild-indigo. Monroe Township, Madison County. Mrs. Bayard Taylor.

1126. **Psoralea onobrychis** Nutt. Sainfoin Psoralea. Near Rome, Franklin County. Mrs. Bayard Taylor.

1135. **Stylosanthes biflora** (L.) B. S. P. Change name to Stylosanthes riparia Kearney. Decumbent Pencil-flower. All of our specimens belong to this species.

1166. **Vicia sativa** L. Common Vetch. Brush Lake, Champaign County. John H. Schaffner.

1173.1. **Lathyrus latifolius** L. Everlasting Pea. Escaped from cultivation along road near Columbus, Franklin County. John H. Schaffner.

1180.1. **Strophostyles pauciflora** (Benth.) Wats. Small Wild Bean. On gravel railroad road-beds. Valley Junction, Hamilton County. E. Lucy Braun.

1187. **Micranthes pennsylvanica** (L.) Haw. Pennsylvania Saxifrage. Hillsboro, Highland County. Katie M. Roads.

1189. **Sullivantia sullivantii** (T. & G.) Britt. Sullivantia. Abundant at Fort Hill, Highland County. Katie M. Roads.

1190. **Tiarella cordifolia** L. False Miterwort. Ironton, Lawrence County. Lillian E. Humphrey.

1243. **Liquidambar styraciflua** L. Sweet-gum. In a wood near Hillsboro, Highland County. Heber Newell and Katie M. Roads.

1263. **Castanea dentata** (Marsh.) Borkh. Chestnut. On ravine slopes, glacial till soil. Milford, Clermont County. E. Lucy Braun.

1287.1. **Hicoria pecan** (Marsh.) Britt. Pecan. Indigenous on alluvial flats. Miami River, Symmes Corner, Butler County. E. Lucy Braun.

1344. **Raimannia laciniata** (Hill.) Rose. Cutleaf Evening-primrose. Barnesville, Belmont County. Emma E. Laughlin.

1356. **Myriophyllum heterophyllum** Mx. Variant-leaf Water-milfoil. Brush Lake, Champaign County. John H. Schaffner.

1383. **Dodecatheon meadia** L. Shooting-star. Ludlow Falls, Miami County. Coll. S. E. Horlacher.

1386. **Pyrola elliptica Nutt.** Shinleaf Wintergreen. Small patch on steep north-facing slope, yellow sandy earth, mesophytic woods. Hazelwood, Hamilton County. Reported by E. Lucy Braun.

1389. **Chimaphila maculata** (L.) Pursh. Spotted Pipsissewa. On black sandy soil, Mesophytic woods. Hazelwood, Hamilton County. E. Lucy Braun.

1420. **Phlox pilosa** L. Downy Phlox. Ironton, Lawrence County. Lillian E. Humphrey.

1432.1. **Convolvulus fraterniflorus** Mack. & Bush. Short-stalked Bindweed. West of Barnesville, Belmont County. Emma E. Laughlin.

1433.1. **Convolvulus repens** L. Trailing Bindweed. On prairie openings on bluffs. Miamiville, Clermont County. N. Mildred Irwin.

1444. **Cuscuta paradoxa** Raf. Glomerate Dodder. Southwest of West Jefferson, Madison County. Mrs. Bayard Taylor.

1479. **Apocynum pubescens** R. Br. Velvet Dogbane. Put-in-Bay Island, Ottawa County. M. E. Stickney.

1497.1. **Nicotiana alata** Link & Otto. Flowering Tobacco. Persistent in Hillsboro, Highland County. Katie M. Roads.

1508. **Physalis pubescens** L. Low Hairy Ground-cherry. Hillsboro, Highland County. Katie M. Roads.

1513. **Solanum dulcamara** L. Bittersweet. Hillsboro, Highland County. Katie M. Roads.

1519. **Scrophularia leporella** Bickn. Hare Figwort. Ashtabula County. Collected by W. A. Kellerman in 1899.

1535. **Veronica anagallis-aquatica** L. Water Speedwell. In stagnant streams near Hillsboro, Highland County. Katie M. Roads.

1544. **Veronica agrestis** L. Garden Speedwell. On lawns, Carthage, Hamilton County. E. Lucy Braun.

1554. **Dasistoma lævigata** Raf. Entire-leaf False Foxglove. Fort Hill, Highland County. Katie M. Roads.

1604. **Onosmodium hispidissium** Mack. Shaggy False Gromwell. Ten miles southeast of Barnesville, Belmont County. Emma E. Laughlin.

1607. **Echium vulgare** L. Blueweed. Near Prospect, Marion County. Also in Radnor Township, Delaware County. Blue and also white forms. Mrs. Bayard Taylor.

1610. **Verbena angustifolia** Mx. Narrowleaf Vervain. Upper Arlington, Columbus, Franklin County. John H. Schaffner.

1646. **Cunila origanoides** (L.) Britt. American Dittany. Fort Hill, Highland County. Katie M. Roads.

1684. **Alyssum alyssoides** L. Yellow Alyssum. On dry gravel soil. California, Hamilton County. E. Lucy Braun.

1687. **Salvia lancifolia** Poir. Lance-leaf Sage. Near West Jefferson, Madison County. Mrs. Bayard Taylor.

1754. **Houstonia longifolia** Gærtn. Longleaf Houstonia. Put-in-Bay Island, Ottawa County. M. E. Stickney.

1760. **Diodia teres** Walt. Rough Buttonweed. Common in New Market Township, Highland County. Katie M. Roads.

1773. **Sherardia arvensis** L. Blue Field-madder. Put-in-Bay Island, Ottawa County. M. E. Stickney.

1810.1. **Campanula trachelium** L. Nettle-leaf Bellflower. West Jefferson, Madison County. From Europe. Mrs. Bayard Taylor.

1856. **Helianthus petiolaris** Nutt. Prairie Sunflower. In field near Hillsboro, Highland County. Katie M. Roads.

1874.1. **Cosmos bipinnatus** Cav. Cosmos. Along a road near Columbus, Franklin County. John H. Schaffner.

1880. **Silphium laciniatum** L. Eliminate the record from Madison County given in Additions to the Catalog of Ohio Vascular Plants for 1919. A mistake was made in identification. The plant is Silphium terebinthinaceum pinnatifidum (Ell.) Gr., see 1882a. below. An authentic specimen of S. laciniatum L. is in the herbarium from Ira, Summit County. Collected by James S. Hine.

1882a. **Silphium terebinthinaceum pinnatifidum** (Ell.) Gr. Common in several localities west of West Jefferson, Madison County. Specimens also from Springfield, Clarke County, collected by Mrs. E. J. Spence and from Plain City, Madison County, collected by W. A. Kellerman.

1886. **Helenium nudiflorum** Nutt. Purple-head Sneezeweed. Portsmouth, Scioto County. W. F. Gahm.

1888. **Bœbera papposa** (Vent.) Rydb. Fetid Marigold. Canaan Township, Madison County. Common along road. John H. Schaffner.

1928.1. **Callistemma chinensis** (L.) Skeels. China-aster. Persistent after cultivation. Hillsboro, Highland County. Katie M. Roads.

1931.1. **Aster schreberi** Nees. Schreber's Aster. Clay banks, borders of woods, Milford, Clermont County. E. Lucy Braun.

1994. **Chrysanthemum parthenium** (L.) Pers. Common Feverfew. Put-in-Bay Island, Ottawa County. M. E. Stickney.

2005. **Artemisia pontica** L. Roman Wormwood. Escaped. Prairie Township, Franklin Co. John H. Schaffner.

2015. **Senecio vulgaris** L. Common Groundsel. Common as a weed in waste places west of Columbus, Franklin County. John H. Schaffner.

2043. **Lactuca saligna** L. Willow Lettuce. New Market Township, Highland County. Katie M. Roads.

2051.1. **Nabalus serpentarius** (Pursh) Hook. Lion's foot (Rattlesnake-root). Old Washington, Guernsey County. Emma E. Laughlin.

2056. **Hieracium paniculatum** L. Panicled Hawkweed. Ravine slopes, mesophytic woods. Hazelwood, Hamilton County. Reported by E. Lucy Braun.

2064. **Crepis capillaris** (L.) Wallr. Smooth Hawksbeard. Waifs in Columbus, Franklin County. John H. Schaffner.

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A PRELIMINARY GENERAL SURVEY OF THE MACROFAUNA OF MIRROR LAKE ON THE OHIO STATE UNIVERSITY CAMPUS.*†

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Ohio State University.

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PART I.

INTRODUCTION.

The present work was undertaken with the purpose of making as extensive a survey as possible, in the limited available time, of the fauna (exclusive of the microscopic part) of a pond on the Ohio State University campus, known as Mirror Lake. Though much general collecting has been done in this pond and an extensive study of the aquatic Hemiptera made

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† Contribution number 63, from the Department of Zoology and Entomology, Ohio State University.

by Mr. C. J. Drake, in his study of that group in Ohio, no systematic survey of its fauna has been attempted, except for the Protozoa, which have been worked out recently by Miss Mabel E. Stehle, (1920).

Collections were made between March 1 and October 18, 1919, at regular intervals of two weeks and with other occasional special collections. Realizing that an entire year's careful collecting, or more, would be necessary to get adequate data for an ecological study, the writer does not consider the work an ecological, but primarily a faunal survey, with merely a few ecological notes.

For purposes of systematic collecting, definite stations were established, all selected with a few of furnishing examples of all types of habitat that seemed possible or worth while to differentiate. Stations are described below (pp. 141–144), indicated on the map (Plate I), and referred to by number in the body of the paper and in the table.

Collecting was done with a large, fine-meshed, long-handled dipnet, occasionally assisted by a smaller fine sieve strainer. In taking material at any station, water was strained through, the mass cursorily examined for all larger forms, and a good part of the mass of mud, algæ, duckweed, or whatever the material harboring the small forms, taken and put into a glass pint or quart jar labeled for the particular station. Water was dipped into the jar to fill it and thus some plankton forms probably secured which would not have been retained in the net. At successive collections the same area in each station was worked.

In the laboratory each jar was worked over by making many successive dilutions of parts of the entire haul, in a large, shallow glass dish, during which process, all animals were secured with forceps or pipette, and put into large vials of 70% alcohol, labeled according to station and date. This was done at once to prevent injury to specimens in close confinement in the jars. Later each vial was examined, the various kinds of animals separated and put into smaller vials of alcohol for permanent preservation. Separation could of course, not be done to species with any certainty whatever. The idea was to separate enough to approximate that ideal of having specimens, when identified by specialists, in individual vials unmistakably named to species.

This survey was not a quantitative one. But usually all animals of a kind were collected as far as practicable. Numbers of individuals are noted for all species listed in the table. Actual numbers alone may not signify much. If there are 10 crayfishes and 10 midge larvæ in a collection from one station, the real interpretation of these equal numbers would be that the crayfishes were abundant and the midge larvæ rather scarce. Relative abundance of these and all forms in balanced natural situations should be known and also environmental conditions in the body of water in question. Consequently in the body of the paper, use is made when possible, of the terms rare, few, many, common, abundant and sometimes other qualifying words. There always exists the difficulty of varying interpretation of these words, but this objection is outweighed by the value of the terms used in a way which carries some proper comparative significance for the various animal kinds and groups.

Groups of animals not covered in the work of this survey are mentioned here and not further referred to: Protozoa, (Stehle '20), Rotifera, Gastrotricha, Nematoda.

Compound microscope and binocular could not be used in the rather hurried work of separation and preservation, though they were later used in such identification of groups as the writer could do. Entomostraca could be detected and transferred without the lens. They are included in the survey, but the list is necessarily very incomplete, as no tow net was used and no real plankton survey made. Only those taken in the collecting above described were available. Ostracoda were omitted, for none were seen except some in jars containing material from Mirror Lake that had been in the laboratory for some time, and which hence undoubtedly represented a development under certain favorable conditions not exactly duplicated in the pond at the time.

Among Vertebrata comparatively little collecting was done. Fishes were obtained in two seinings, Sept. 27 and Oct. 4, 1919. Some vertebrate records were merely based on notes of specimens seen or on positive evidence of their presence. Amphibia were collected in the spring of 1920.

Among Invertebrata, several small groups, of which specimens were expected, were not at all represented in the collections, namely Bryozoa, and among Insecta, the Gyrinidæ.

Insecta, the largest single group, receive more emphasis than any other group.

ACKNOWLEDGMENTS.

In a survey involving necessarily so large a part of the animal kingdom, the writer had to have the assistance of a number of zoologists to make determinations in groups in which they are specialists. The writer is glad to be able to credit identifications to so many eminent specialists. To those who kindly did this work and to all who helped in any way, the writer wishes to express his great appreciation and thanks.

Among insects various groups were identified as follows: Prof. J. W. Folsom, Collembola; Dr. C. H. Kennedy, Odonata, and mayfly nymphs; Dr. J. W. Malloch, Chironomidæ, larvæ and pupæ; Dr. H. G. Dyar, through the kind suggestion of Dr. L. O. Howard, mosquito larvæ and pupæ; Prof. J. S. Hine, some adult and larval Diptera of other families; Dr. Edna Mosher, Coleoptera larvæ; Dr. H. B. Hungerford, Corixidæ; Prof. Herbert Osborn, several Hemiptera and Thysanoptera; Mr. T. L. Guyton, aphids; Dr. C. W. Leng and Dr. H. C. Fall, several Coleoptera; and Mr. C. J. Drake, a water strider.

Among other groups identifications were made as follows: Prof. Frank Smith, Oligochæta; Prof. J. P. Moore, Hirudinea; Dr. V. Sterki, Mollusca; Dr. Bryant Walker, fresh-water mussels; Mr. Chancey Juday, Cladocera; Dr. C. Dwight Marsh, Copepoda; Miss A. L. Weckel, Amphipoda; Prof. Wm. M. Barrows, spiders; Miss Caroline Stringer, a few Turbellaria; Mr. E. L. Wickliff, the fishes; and Prof. E. N. Transeau, the plants.

I am also indebted to Prof. R. C. Osburn for assistance in determining the crayfishes, and help and suggestions relative to fishes; Prof. Wm. S. Marshall for assistance, while studying and comparing beetles with his collection; Mr. T. E. B. Pope, for permission to examine beetles in collections at the Milwaukee Public Museum; Mr. P. R. Lowry, for examination of his collection of aquatic Hemiptera; Prof. Herbert Osborn, for suggestions and literature on Hemiptera; Mr. C. J. Drake for data and suggestions on aquatic Hemiptera; Prof. F. H. Krecker, for suggestions on ecological matters; Prof. Wm. M. Barrows, for suggestions on the same matters and photographing of the map of Mirror Lake; Mr. E. A. Hartley for inking the drawing of the lake; Mr. C. W. McCracken for the loan of the campus map from which this drawing was made; and Prof. R. C. Osburn for various other helpful suggestions.

PART II.

MIRROR LAKE: DESCRIPTION AND HISTORY.

This part of the original thesis form is omitted here, as the account in Miss Stehle's paper ('20), suffices. Points that should be emphasized, however, are: the artificial origin (1872) of the pond, the extensive alterations in 1895, really a second starting point for the fauna and flora, the subsequent development of these, and further changes made during and subsequent to this survey.

On April 16, 1919, after only two collections had been made, a change was wrought in the smaller of the two ponds which constitute Mirror Lake. The narrow neck of land between the two ponds was cut through which lowered the water level in the small pond about ten inches, and left organisms stranded high and dry on the muddy shore. This was to be part of an extensive "cleaning" out and general change in the pond which fortunately did not come to pass while this work was being done.*

PART III.

DESCRIPTION OF STATIONS.

Stations are not discussed in the numerical order in which they were established, but in a natural arrangement which brings together those nearest in position and environmental conditions. The same order is used in the table.

STATION 1. This was a shallow station located off the northeast shore of the small pond. It was a uniform area, a few square yards in extent, not with a soft, muddy, oozy bottom as most of the pond had, but with a partly gravelly, partly muddy bottom, sloping gradually down from the shore-line and only several inches deep on the average.

The lowering of the water level (April 16) exposed a very large part of the station, and left snails, leeches, etc., stranded on the new muddy shore.

* In the summer of 1920, after this study was terminated, the entire plan of altering Mirror Lake was carried out. It was drained, and then refilled after the small pond was completely obliterated, and the same done with the attractive island, the largest curves in the shoreline, and the northwest arm and rustic bridge of the large pond. The entire shoreline (it should be added) was lined with a wall of cobblestones!

Station 11. This was established to replace number 1, which it slightly overlapped along the shoreline. Since most of number 1 was shore, this was out farther, with bottom more muddy and of more pronounced slope.

Station 17. In a slight depression in the flat shore area (former station 1) an accumulation of water late in summer necessitated this new station. The bottom of this little pool was even, sandy and gravelly, and its depth three or four inches. The surface was free from duckweed, even though so close to the duckweed covered pond.

Station 13. This was a spring on the north-east shore of the small pond, enclosed by a cylindrical brick wall, and the top partly covered by a board. It was close to three feet deep, and the water level as high as in the pond, which came practically up to the rim of the spring. After the lowering of the water level, there were several feet between the new pond edge and the spring, in which the water level was lowered almost as much as in the pond. A little water trickled down from it to the pond.

Station 2. This was located in the northwest corner of the small pond. Its sides were both shores of the small indentation that was nearest the large pond. The shoreline was relatively steep and the water deeper than along the northeast and east shores of this pond.

Station 12. The same change referred to above altered number 2 in several ways. The channel dug to connect the two ponds changed the former, little, secluded, duckweed covered bay to an open area, narrowed by the lowering of the water level and having a slightly perceptible current through it at times, towards the large pond. But frequent winds, blowing eastward over the large pond, moved leaves and debris up to this channel opening and practically prevented migration of duckweed from the small pond.

Station 3. This was located off the southwest shore of the small pond. The shore was less steep and solid than other shores except the entire south-east end. The bottom sloped down rapidly and was soft and muddy.

The narrow southeast end of the small pond was low and marshy in its shoreline, the water very shallow and the bottom very mucky and muddy. It was almost choked with fallen

leaves, which, together with constant shade of nearby overhanging trees, seemed to make conditions most unfavorable for animal life. No station was established there.

STATION 4. This was located along the north shore of the large pond where the spring had its outlet. At the point of outlet, the water was only an inch deep and the bottom was gravelly. Throughout the area considered as this station, having a yard radius out from this central point, it was quite shallow, but sloped down at its outer edge to relatively deeper water. In this area the bottom was of uniformly fine gravel, a secondary accumulation. In the deeper water beyond, mud covered the bottom completely. On the shoreline for a short distance along here and beyond this station, is a line of large boulders.

STATION 14. This station, a few feet east of number 4, lacked the deposit of fine gravel along shore, and hence the water was deeper, averaging more than a foot directly off the line of shore boulders. Some projecting roots of an adjacent alder tree, with some accumulation of leaves there, made this a better habitat than at other similar places in the immediate vicinity.

STATION 15. This, located on the north shore of the larger pond about 30 feet west of station 4, was a situation similar to most of the north shore (see description for 7) but here was found overhanging grass, (even some growing in the water), and some accumulation of debris, which offered a slight retreat for a few forms not found elsewhere along this shore.

STATION 5. This station was on the south shore of the larger pond in the deep indentation which extends southward, opposite to station 4. The bank was fairly firm and about a half foot above the water's surface. The bottom here was very soft and muddy. The water throughout this bay was somewhat stagnant as it was not moved by the winds which disturbed the main east-west stretch of this pond.

STATION 6. This station also lay along the south shore, but on the end of the projecting peninsula between the bay just referred to and the main part of the large pond. Here the water was clear and relatively deep. There was some undercutting in the clay bank, projecting roots and some overhanging grass.

STATION 7. This station located on the north shore of the large pond was about sixty feet east of the east approach to

the rustic bridge. Here and along most of the north shore, the shallow shoreward waters were filled with large irregular stones, some projecting a little. The shore itself was a grassy bank a foot above the pond surface. The area of submerged stones along the shore extended out from 3 to 6 feet beyond which the water was deeper and the bottom muddy.

Station 16. This station was located about 30 feet west of 7, or half way between it and the bridge, at the point where this shore projected out farthest. It was established solely because of the discovery of fresh-water sponge on a stone at this place.

Station 8. This station was located on the south shore of the large pond just opposite the west end of the island. The water was fairly deep even close to shore, and the latter a grassy bank rising steeply to form a hill. Some large, submerged stones made a rocky border similar but narrower than that on the opposite shore.

Station 9. This station was located at the northwest end of the lake just west of the small island over which passed the rustic bridge, just south of which it was. The water was very shallow, the bottom muddy and with some sand and debris accumulated there. But the layer of mud here and north of the bridge, throughout the northwest arm of the lake, (which was also shallow) was not very deep. But beyond the end of the little island, the bottom had a declivity and beyond that, as elsewhere in the large pond proper there was a deep bottom layer of dark brown or black mud. Only a part of the shallowest part was taken at this station. There algæ and some grasses grew.

Station 10. This station was located at the southwest end of the large pond, directly around the iron pipe that was the outlet of the pond. The water was shallow, the bank and bottom of clay with a few stones submerged near shore.

PART IV.

ECOLOGY OF MIRROR LAKE.

A. *The Flora of Mirror Lake.*

It is only as an environmental factor that plants are considered in this survey. As with the fauna, the microscopic flora was not collected or observed.

The large pond was practically free of larger algæ as well as of higher plants, except for some favorable littoral situations.

Covering all of the upper surfaces of submerged rocks (as noted along most of the north shore) were good growths of filamentous algæ, including *Spirogyra* of several species, and *Cladophora fontanemus*, (rocks at station 4), *Spirogyra fluviatilis*, and *Oedogonium*, (rocks at station 7). *Cladophora* and *Oedogonium* were found on rocks at station 6. In the shallow waters of station 9, both on small stones at bottom and forming masses drifted in towards shallowest part were various species of *Spirogyra*. Directly north of the wooden bridge were *Mougeotia sphærocarpus* and *Spirogyra* of various species including *S. cateniformis*.

In the small pond a great development of plants took place each summer. Extensive growths of *Spirogyra*, *Cladophora*, *Vaucheria*, and *Oscillatoria limosa*, were found in this water. A complete list is not available as material for determination was collected only once, rather late in summer.

The duckweed, *Lemna minor*, beginning in small isolated groups of leaflets in spring, multiplied rapidly and by late summer formed a dense mass like a green carpet covering the water. The duckweed seemed to obliterate the algæ to a marked extent. Only along station 3 was there an area free from it. There were practically no other higher aquatic plants present.

Along the shore of the small pond grasses grew luxuriantly, and by fall these encroached upon the water. The chief grasses were *Dactylis glomeratus* (orchard grass), and *Leersia oryzoides* (saw grass or rice cut grass). Small patches of these were found in very shallow water just off shore, in the southern end of the small pond, at station 12, and likewise north of station 9 and of the rustic bridge in the large pond. Bur marigold, *Bidens connata* mingled with grasses along shore especially where much moisture prevailed.

B. Ecology of the Pond as a Whole.

Mirror lake, so artificial in origin and history could not well be compared directly with natural ponds or lakes. The larger pond was hopelessly artificial for the most part (and is more so now) lacking in many environmental factors that would make favorable habitats for many types of animals. The scarcity of animal forms found there amply illustrates that. The smaller pond soon outgrew its artificial aspect. The shoreline was less artificially maintained and a good development of plant life of some kinds allowed.

The formations or habitats of typical ponds Shelford ('13), enumerates as: (1) pelagic formation (better called limnetic), (2) pioneer formation, (terrigenous bottom), (3) submerged association, and (4) association of emergent vegetation.

Number 1 was present in Mirror Lake, though little represented in the small pond. As terrigenous bottom means a bare bottom, which eventually gives way to rooted vegetation, number 2 was, strictly speaking, not present. Except in the shoreward areas the bottom was soft, dark mud, with humus added to it. Number three was developed in the small pond (comprising algæ only) but practically absent in the large. Unless one consider the slightly submerged shore grasses in parts, number four was also absent.

From the standpoint of the development of a typical pond fauna the greatest deficiency was this of the emergent vegetation, which implies shoreward areas of cat tails, rushes, arrow heads, etc., and water lilies on the open water side. Ponds richest in life have a good development of such association together with a submerged association.

The large pond (with the exception of station 9 and vicinity) lacks characteristic floral and faunal features of ponds which, by Shelford's ('13) definition "are usually very largely captured by vegetation which is very much like that in the bays of lakes." Neither is it a lake. It is just an artificial body of water, called pond rather than lake, because of its small size, which, cannot be made to conform closely to anything in nature.

C. Ecological Habitats and Grouping of Stations Into Habitats.

Division into ecological habitats is especially difficult where the body of water is so generally of a uniform nature as is the larger part of Mirror Lake.

Needham and Lloyd's ('16) classification of habitats of ponds, satisfactory and sufficient at the same time for ecological habitats and societies of animals is: (1) Littoral, or shoreward area, with its divisions (a) Lenitic or stillwater societies, and (b) Lotic or rapid water societies; and (2) Limnetic, or open water area, with its divisions (a) Plankton and (b) Necton, the latter referring to the group of large free swimming animals. Naturally no lotic area or conditions were present in the pond.

The limnetic region in the large pond was extensive. A true pond fauna, with insects, etc., as an important part would be absent in a limnetic region. The necton, consisting here entirely of fishes, was important, especially since the fishes were rather too abundant and effective in reducing numbers among other free swimming organisms. The plankton, which would be very important, was not surveyed, except for such organisms as ranged in the littoral zone. In the small pond there was no true limnetic area at least not in its true sense, except when the vegetation and especially the duckweed covering was not developed early in the season.

The littoral region, of prime importance in a typical pond, was very much reduced in width in the large pond. While all the stations here were in the littoral zone, as far as position is concerned, results showed that stations 10, 8, 4, and to a smaller extent, 16, 7, 6, and 5, (in about that order) were more or less deprived of a fauna, except for a few surface forms (such as water striders) which might, occasionally or frequently, be there, and some possible bottom forms that may have been missed. The shoreline in part at least, was not unsatisfactory, and there might have been more evidence of the "sheltering influence of shore," if there had been somewhat more vegetation, and fewer fishes, which invade even to the shoreline. The broad row of large, submerged stones along the north shore offered good environment for lithophilous forms.

In the smaller pond also the littoral region, included all collecting stations, and included, when duckweed covered the surface, practically the whole pond; or at any rate the pond was more nearly of the littoral type than anything else. The lack of emergent, rooted vegetation would not be typically littoral. The bottom mud was deep here, but no deeper than in the large pond, and it had a larger deposit of humus.

PART V.

GENERAL SYSTEMATIC SURVEY OF THE MACROFAUNA WITH NOTES ON THE VARIOUS SPECIES.*

Phylum PORIFERA.

Spongilla fragilis Leidy. Fresh-water sponge was found on only one of the large, submerged stones, on the north shore of the large pond. The flat, gray, incrusting colonies were irregularly rounded, filling the uneven depressions of the lower surface.

Phylum CŒLENTERATA.

Hydra viridissima Pallas (*H. viridis* L.), was found, but was evidently rare.

Hydra oligactis Pallas, (*H. fusca* L.), was somewhat better represented. Undoubtedly it was more common at times than these collections showed.

Phylum PLATYHELMINTHES.

Class TURBELLARIA.

Planaria gonocephala Duges, was the only species of the Tricladida found, and the few specimens were all from the lower surface of a large, flat, submerged stone, on the north shore, station 7.

The reason for the meagre lot of individuals and of species of flatworms, was the insufficient and unvaried food supply.

Dalyellia sp. was found merely by accident in examining some pond water microscopically. This and others of its group were very likely common in parts where algæ abounded.

Phylum NEMATHELMINTHES.

Class GORDIACEA.

Paragordius varius (Leidy). One adult found in algæ near the water's surface in the small pond was the only representative of the group taken in the entire survey. No special search was made for the parasitic larvæ.

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* For the numbers of specimens of all aquatic species found at the various stations, see the Table.

Phylum ANNELIDA.

Subclass OLIGOCHÆTA.

Order Microdrili.

Some worms of this group are among the most abundant animals in the entire pond. They could be compared favorably with midge larvæ, but since a good habitat which no doubt harbored myriads of some members of both groups, namely the bottom mud of the large pond, was hardly touched, no real estimate of relative numbers could be formed. The almost total absence in the large pond as compared with the small, of the mud-dwelling forms (Tubificidæ), is thus explained. Forms dwelling where algæ and other vegetation abounds, (Naididæ) would of course not be expected from most of the large pond.

Family *Naididæ.*

Chætogaster sp. This was among the scarcer forms of this family. The species could not be determined because of the immature condition of the specimens.

Slavina appendiculata (d'Udekem) (?). Worms of this genus, which were more numerous than the foregoing, could not be positively identified to species.

Nais sp. These tiny, transparent worms were the most abundant of the family. The largest number was found in the very shallow water of station 11, and chiefly in late spring. None were mature enough for specific determination.

Dero limosa Leidy. While it is very likely this species, only living material, (which was not available when Prof. Smith named them), would make determination positive in this genus. With a very few exceptions none of the specimens secured had the characteristic case built by Dero.

Family *Tubificidæ.*

Limnodrilus sp. This was one of the most abundant animal forms in the entire pond. Though not quite as many specimens were collected as of Nais, it must be remembered that only a very small part of its habitat was touched. They were quite evenly distributed throughout the collecting period. None were mature enough for accurate specific determination. Possibly all belonged to one species, which is at least very closely similar to *Limnodrilus hoffmeisteri* Claparede, found in Europe and also in this country.

Tubifex multisetosus (Smith). This genus, possibly about half as abundant in the pond as is Limnodrilus, was fully nine-tenths of this one species. Some specimens Prof. Smith found exceptionally mature and desirable for identification.

Tubifex tubifex (Müller) = (Tubifex rivulorum Lamarck). A few were identified as very likely of this species.

Aulodrilus pluriseta Piguet (?). Prof. Smith, who found two specimens of this among my Oligochæts, reports this as the first record of the occurrence in the United States of this genus. While the species is doubtful, it is at least similar to *A. pluriseta* Piguet, of Switzerland. The position of Aulodrilus is tentative; in fact its family relationships are problematical because its reproductive organs have not been studied. Smith reports that Piguet first put it among the Naididæ, and subsequently among the Tubificidæ, where it may remain for the present.

Apparently it is rare in this pond. Nothing more can be said than that the specimens were obtained with some of Tubifex, Dero, and Nais, station 11, June 5. Piquet (as Smith reported) describes these worms as living in the little tubes formed by particles of debris, held together by secretions, from the surface layer of the worm. When separated from their tubes they do not use the old ones again, but build new ones.

Order **Megadrili.**

Helodrilus caliginosus var. trapezoides (Duges). This, (Smith '17) the most abundant and most widely distributed American earthworm, abounding in the bottom lands of rivers, as well as less moist earth, was found in Mirror Lake in small number near the shoreline. These and a couple of other Lumbricids, (Helodrilus sp.) taken from the pond, undoubtedly were in the water by accident; hence they are not listed among the aquatic forms.

Class Hirudinea.

Leeches were well represented in Mirror Lake, considering the small size of the group.

Order **Rhynchobdellida.**

Family *Glossiphonidæ.*

Glossiphonia stagnalis (Linn.). This, (Moore '12) "abounds especially in warm, shallow waters of streams, pools and ponds; it is the common pond leech." It was the commonest leech in

Mirror Lake, abundant in fact, and more so than the numbers in the table would indicate. During most of the collecting period it could be found attached to dead leaves and a variety of other objects on the bottom of the small pond. Several females with egg masses attached ventrally, were taken in April and a considerable number of very young ones in May.

Glossiphonia fusca Castle, another small leech of similar habitat, was rare. Only one individual was taken during the entire survey.

Placobdella rugosa (Verrill). Only one rather small specimen of this "rough leech" was found. Undoubtedly it was rare here.

Order **Gnathobdellida.**

Family *Herpobdellidæ.*

Herpobdella punctata (Leidy) This large leech was common, but no complete idea of how numerous it was could be formed because of its bottom dwelling habit. Its swimming powers it never seemed to use. It could not have been entirely absent from the bottom of the large pond, even though the collections disclosed none there. Most of those secured would have been missed had it not been for the lowering of the water level in April, which stranded many on the newly exposed mud at station 1.

Phylum BRYOZOA.

Collections from Mirror Lake disclosed no specimens of the small but common group of fresh-water Bryozoa, though favorable places for attachment existed in great number, and were examined closely. A specimen of *Plumatella polymorpha* Kræpalin, on a Physa shell, was observed in an aquarium in the laboratory. The snail was believed to have come with other material from this pond; but this is not sufficient basis for inclusion in the pond list of species.

Phylum MOLLUSCA.

Class Gastropoda.

Order **Pulmonata.**

The small pond was a favorable habitat for snails, principally because of the vegetation there. The large pond on the other hand was very unfavorable not only because of the lack

of vegetation suitable for pond species, but also because among the fishes which were present, were some which would feed on snails. (Baker '16).

Kinds of snails were rather few, but the group as a whole, because of good numbers among some species, was fairly prominent.

Dr. Sterki named quite a few specimens with a reservation but the writer includes definitely all specimens identified, in the species he referred them to. The numbers in the tables give very little idea of the total. Only a portion of all collected were identified.

Family *Lymnæidæ*.

Lymnæa obrussa Say. Only a few of the identified lot of Lymnæa were of this species, and probably it was rare. Specimens were practically full grown.

Lymnæa humilis Say. This was the common member of the genus; four-fifths of the identified Lymnæa were of this species. In comparison with the more numerous Physa, it could at best be called fairly common.

Lymnæa humilis rustica Lea (?) This was represented by a single specimen. Unquestionably it was rare.

Lymnæa humilis modicella was represented by two specimens; also rare.

Lymnæa parva Lea. (?) Only one specimen and doubtfully that, was found of this species.

Family *Physidæ*.

Physa gyrina Say. This well known species proved to be common, somewhat more so than Lymnæa humilis, judging from identified material. It was found at practically all stations in the small pond.

Physa heterostropha Say. This was the most abundant species of snail present. About three times as many were obtained as of P. gyrina, and they were secured at all stations in the small pond.

Physa integra Haldeman. Relatively few specimens were found and this species must be ranked as rather uncommon.

Vallonia pulchella Müller. A specimen of this purely terrestrial snail was accidentally in the water at station 11.

Class Pelecypoda.

Order **Eulamellibranchiata.**

Family *Unionidæ.*

Anodonta grandis Say. This large mussel was an inhabitant of the mud bottom of the large pond, but was not secured or even noticed until the draining of the pond, June, 1920, when two large pails full of specimens, 55 in number, were obtained. No doubt many others were present especially towards the center, so that the species can be easily considered common.

Family *Sphæriidæ.*

Musculium transversum (Say). This was the only small bivalve in the pond. At least, in the material identified, all specimens, though none were mature, could quite certainly be referred to this one species. It could be considered common in the small pond (where all specimens were taken) or even abundant for certain areas there, namely stations 12 and 3. None were secured elsewhere. Station 12 was the most favorable locality; the mud was not too deep and glutinous and had a surface layer of the so-called dust fine detritus. This was hardly apparent at station 3, but on the other hand was quite common too, along the east shore.

Phylum ARTHROPODA.

Class Crustacea.

Subclass Entomostraca.

All orders having fresh-water forms except Phyllopoda are present in Mirror Lake. Ostracoda are not included in the survey as stated in the introduction.

Suborder **Cladocera.**

Only two species were found in Mirror Lake. In spite of the unfavorable features of the pond, probably more could be expected, since Cladocera thrive in sheltered pools and ponds where food is abundant, live in the littoral region and (Birge '18) "among the weeds and feeding on algæ, and similar organisms." Practically all were taken from the small pond. Possibly other, smaller forms, commoner in open water, were missed.

Simocephalus serrulatus (Koch), said to be (Birge '18) the most abundant species of the genus was found only at station 3, principally in June. It was not common.

Simocephalus vetulus (O. F. Müller), said to be "not very abundant," but likely to be found anywhere where vegetation thrives, was found decidedly more common here and at more places in the small pond.

Order **Copepoda.**

This order, though with a smaller number of specimens collected, was somewhat better represented in species than Cladocera. Similarly there may have been limnetic forms entirely missed.

Cyclops bicuspidatus Claus, was the species most numerous in individuals and ranked as common. As Marsh noted it has its optimum in cold water, and all specimens were taken from Mirror Lake early in spring, none after April 16, when the temperature was 14° C. At the next collection, May 3, the temperature of the water was 16° C.

Cyclops albidus Jurine, was much less common; only a third as many as of *C. bicuspidatus*, were collected.

Cyclops serrulatus Fisher, was not uncommon and ranked midway in numbers of individuals between the other two species, as far as the collection could show.

Subclass Malacostraca.

Order **Isopoda.**

Family *Asellidæ.*

Asellus was found quite common, and almost exclusively in the waters of the small pond together with the spring, station 13. It was found in masses of submerged algæ, on Lemna roots, debris and on the bottom.

Why nearly half of all Asellus material was secured from this spring, is not clear. There was less vegetation in it than in the pond, hence less food, and the bottom was no better. The temperature conditions might explain it. The temperature of the water in the spring from May 17, when the first collection was made there, to Oct. 4, was from 1° C. to 5° C. colder than in the pond. The most difference occurred in June; the least in October. At every collection in this period specimens were found in the spring and pond. On October 18, (date of the last collection) Asellus was found in the spring only, and the temperature of the water there was 2° C. higher than in the pond; but since the water in the pond was 7° C. colder than at the

preceding collection, the temperature in the spring, though lower than in summer, was more nearly like its preceding, prevailing temperature; that is there was less variation in the spring than in the pond. The difference in summer temperatures might seem negligible, but in winter the difference might have been of more consequence. No winter temperatures were taken but the spring water was never frozen and obviously of higher temperature than the shallow pond. Possibly the higher winter temperatures and the smaller variability in temperatures throughout the year explains the matter.

Asellus communis Say, was not uncommon. More than half were found in the waters of the spring.

Asellus intermedius Forbes, a smaller species, was far more common. Collections showed three times as many as of the more conspicuous *A. Communis.* A number of times (April 3, 16, May 7, and June 28) mature females were found which bore a brood sac filled with eggs on the ventral side of the body.

NON-AQUATIC ISOPODA.

Oniscus asellus Linn. (*Oniscidæ*). This common terrestrial sow bug, is not known to occur in water, though it inhabits moist earth. But one specimen was found in the water of the spring, station 13.

Armadillidium vulgare (Latreille). (*Armadillididæ*). Several specimens of this terrestrial pill bug, inactive, rolled up, but alive, were taken from the water, station 13. These, as well as the preceding, were doubtless there by accident.

Order **Amphipoda.**

Eucrangonyx gracilis (Smith). This was the one species of the order represented in the pond, and by only a small number of specimens. It was restricted to parts of the small pond, and none were taken later than April. Two out of six specimens carried a large egg mass on the ventral side of the thorax.

Order **Decapoda.**

Family *Potamobiidæ.*

Cambarus rusticus Girard. This, one of the commonest species in the region in a variety of situations (Osburn and Williamson, '98) was the only species which could be considered common, and that only on the basis that they were more numerous than the dipnet collecting revealed. Forms so well hidden in the mud as crayfishes, would be easily overlooked. Four out of five individuals sufficiently large for identification

were of this species. (A number of very young ones were too small and undeveloped for determination). The only male crayfish found was a half grown one of this species, from the mud of station 11. The others were females, two small ones and one quite large, all in soft shelled condition. All were from the small pond.

Cambarus bartoni robustus (Girard). Only one specimen of this species was found, a female of medium large size, taken at station 13. As this is a common "brook species," found among stones in rapidly flowing streams, (Pearse, '09) its presence in Mirror Lake was somewhat surprising, though it should be noted that having been found among stones near the north shore of the large pond, it was not as far from its habitat as it would have been in the small pond.

Class Insecta.

The aquatic members of this class living in Mirror Lake were so numerous in kinds and individuals that they actually formed the dominant assemblage of animal inhabitants of the small pond, though they were reduced to a place of minor importance by the fishes in the large pond. Most orders, including aquatic forms, were represented here.

Order **Collembola.**

Springtails apparently were not abundant on the pond as a whole, but when found at some restricted area, as happened a few times, they were abundant in those places.

Sminthurides aquaticus (Bourlet) was a rare species; only one specimen was so identified out of all Collembola obtained.

Isotoma palustris (Müller) was a species of undoubtedly uncommon occurrence also; only three specimens were secured.

Podura aquatica Linn., was the most numerous by far of the Collembola here. It was abundant a number of occasions at some areas, and with better collecting methods decidedly more would have been obtained than the table shows. Possibly smaller and hence less conspicuous numbers were present in other parts of the pond also.

Order **Ephemerida.**

Larval stages only were taken, of the mayflies. No adults were noticed, not even a trace of their bodies after their ephem-

eral existence, or of the cast nymphal skins. Specific determination unfortunately was not possible. Very young specimens were not included in the genus identification and hence not counted in the table.

Hexagenia sp. Two specimens of a large species of burrowing nymph, were uncovered at the time of the draining of the lake, June, 1920. They would not have been recorded otherwise. They were partly in the mud, some distance from shore, near the west end of the large pond, nearest station 9. It was probably scarce in Mirror Lake.

Heptagenia sp. A few specimens of this were found clinging on the under surface of a large, submerged stone (station 7). Since this sort of habitat could easily be investigated and no more were disclosed, it must be deemed rare.

Cænis sp. This form was found at various points off shore on the bottom mud and silt, chiefly in the large pond. Though only a small number were secured probably it was not uncommon. The large pond may have harbored many, so as to have made it more common than Callibætis.

Callibætis sp. This form, (Needham '18), "an active climber among green vegetation," was found almost exclusively in the small pond, at a number of stations. It was common. An odd occurrence was a relatively large number in the shallow open water of station 17.

Order **Odonata.**

Adult dragon flies and damsel flies were common about the pond most of the season. Damsel flies especially were seen hovering over grasses on the margin. There many were collected several times during the summer. Dragon flies were not taken; those commonly present were recognized. A few strong fliers, seen only occasionally, are not listed, as very likely their early life history was not lived in the pond. Of the entire order, only such species of which nymphs were obtained from Mirror Lake are listed, except one or two, which unquestionably must have passed their early life history there. It is likely that not as comprehensive a collection of dragon fly nymphs was secured, because of their generally obscure haunts, as of the damsel fly nymphs.

Suborder **Zygoptera.***

Family *Agrionidæ.*

Argia violacea (Hagen). Nymphs of this species, unlike others of the Argias, and more like Lestes and Enallagma, could have been expected in good number in the small pond, for conditions there were ideal. "It oviposits" (Needham '03) "commonly in mats of algæ at the edge of the water or covering floating vegetation." Nymphs were rather few, all found in September, while the adults, not numerous either, were taken in the early half of summer.

Enallagma antennatum (Say). These nymphs were the most numerous in the pond; the species can certainly be listed as common. But as for adults only a very few were of this species. The discrepancy was largely due to the peculiar flight of this species close to the water line and directly through the shore vegetation (Needham '03), whence they were unwittingly overlooked while collecting more conspicuous fliers.

Enallagma exsulans (Hagen). This species was rare. Only one nymph and no adults were obtained.

Ischnura posita (Hagen). This species was less common than *E. antennatum.* Nymphs were most common early in the season. Adults were scarce at the time collections were made.

Ischnura verticalis (Say). This was a very common species and possibly it was more abundant than *E. antennatum* or at least equally common. Fewer nymphs but many more adults of this species were secured.

Suborder **Anisoptera.†**

Family *Libellulidæ.*

Libellula pulchella Drury. This was the commonest of the dragonflies. Adults were noticed often during the summer, and nymphs, though not numerous compared with the commonest damsel fly nymphs, were more numerous than all others of the suborder put together. With one exception all nymphs were from the small pond.

Libellula basalis Say was common about the pond but no nymphs whatever were secured.

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* Figures in table are of the nymphs collected that were identified. This excludes a very large number of small nymphs. Since adults were not collected at these definite stations, they are omitted from the numbers given in the table.

† Figures in the table are of the collected nymphs which were identified, except that Pachydiplax (represented by only one adult) is added.

Plathemis lydia Drury, was less common than *L. pulchella*. Adults were noticed quite often. Only a few nymphs were secured.

Sympetrum rubicundulum Say. Adults of this, and possibly of other closely similar species, were frequently seen. Reliance was unfortunately put solely on nymphal material. When identification was done only one nymph of this species and of the entire genus was found.

Pachydiplax longipennis Burmeister. A freshly emerged adult of this species was taken off shore at station 15, on April 22, 1920. This was very early in the season for it is reported for not earlier than May and June in Indiana. (Williamson '99).

Order **Hemiptera.**

Suborder **Heteroptera.**

Aquatic bugs, except surface forms, were restricted almost exclusively to the small pond. The group was an important one in the pond and some forms were abundant in numbers of individuals. The number of species was somewhat less than anticipated but very likely practically all species present at the time of the survey were obtained. Drake found also other species during his collecting (1914–1917). In connection with each family discussion, the additional species he found, are mentioned.

For classification and nomenclature, Van Duzee's check list ('16) and Catalogue ('17) have been followed, but in the arrangement of the families the more common and generally used one, such as used by Comstock ('16) was followed.

Family *Corixidæ*.

Water boatmen were almost exclusively found in the small pond and were commonest late in summer. The largest number of individuals came from the spring, station 13.

Arctocorixa alternata (Say). In the collected material as far as identified this was the least numerous of three species found; only a tenth of all Corixids were this. All were taken in station 17.

Arctocorixa scabra (Abbott M. S. sp.) Hungerford found this species much commoner in my material, about four times

as numerous as A. alternata. Most of them were from the spring, station 13.

Corixa verticalis Fieber. This was also a common species, possibly somewhat more so than the preceding. Very few were from the spring, most from the small pond, but also a few from the large pond.

Family *Notonectidæ.*

Notonecta variabilis Fieber. This was the only backswimmer found and only a single specimen was secured in the shallow, vegetationless pool, station 17. It was surprising to find it so rare and other members of the family entirely missing. Since they could not escape detection easily, it is probable that no other kinds were present at the time.

But Drake found a total of six species in a number of years collecting. Of the five, which I did not find, he wrote me that *Notonecta undulata* Say, was most common when he collected. *N. irrorota* Uhl., and *N. insulata* Kirby, both not uncommon, and *Plea striola* Fieber, and *Bueno margaritacea* Bueno rare.

Family *Nepidæ.*

Ranatra americana Montd. This was the only species of the family present. Just three specimens were found, in the slight vegetation and debris off shore at stations 14 and 15. Thorough combing around the large pond failed to disclose any elsewhere than at these favorable localities.

Family *Belostomatidæ.*

None of the largest members of this family were seen, but Drake reported that he found a few *Benacus griseus* Say.

Belostoma (Zaitha) fluminea Say, was the only representative of the family found. Only four specimens were found, so that this form, so generally common, was scarce here.

Family *Saldidæ.*

Micranthia humilis (Say). This was the only representative of the shore bugs found. It was rare, as only one specimen was found.

Drake reported the species fairly common when he collected, and also reported collecting a few *Saldula major* (Prov.) and *Saldula orbiculata* (Uhl).

Family *Mesoveliidæ.*

Mesovelia mulsanti White. This was abundant in Mirror Lake, and second to one of the small Gerrids (see below) the most abundant of all Heteroptera. It was commonest where algæ and duckweed were thick, and chiefly in the latter part of summer. Most of the specimens were taken in September.

Family *Hebridæ.*

This family is represented in local fauna by two species of Merragata described by Drake ('17).

Merragata brunnea Drake, was the only species found at Mirror Lake. Apparently it was rare; only one brachypterous specimen was taken, in among vegetation on the surface close to shore at station 15. None were secured from the small pond where it might have found favorable situations.

Family *Veliidæ.*

Microvelia borealis Bueno. This tiny water strider was common; possibly it should be listed as abundant. At least it was abundant at station 17, September 13, when most of them were found. The little pool was teeming with them, and many more could have been secured than were. While only a few were obtained at other stations, these were fairly well scattered, so that it is quite likely that there were times when they were numerous at more than the one locality.

Drake found ('16) *Microvelia americana* (Uhl.), which he said was more common than *M. borealis* Bueno. He also found a new species, *Microvelia hinei* Drake, recently described (Drake '20).

Family *Gerridæ.*

Gerris remiges Say. Somewhat surprising is the rarity of this water strider, which has been called (Bueno '11) "perhaps the most common of our species." Only one was found. Its large size would prevent its being overlooked.

Gerris marginatus Say. This was the most abundant species of the family next to *Trepobates pictus* and was undoubtedly a close third in general abundance among all Heteroptera. It was taken throughout the collecting period in both adult and nymphal stages. The vast majority were in the small pond and none on the open water of the large pond; those from the large were near shore where vegetation existed. This habitat

of the Gerrids offers evidently a striking contrast to that of *Trepobates*. Half of all specimens were secured at station 3. Larger water striders are often observed to be numerous in shady situations, but if shade was a determining factor here, it could not explain the very common prevalence of this same species at station 11, which had scarcely any shade.

Drake reported that in 1916 he captured also, as relatively scarce among *G. marginatus*, several specimens of *Gerris conformis* (Uhl.), more of *G. buenoi* Kirk., and a few of *G. canaliculatus* Say and of *G. rufoscutellatus* Latreille.

Tenagogonus hesione Kirk. This water strider, first reported for this region by Osborn and Drake ('15) and said by them to be common in the apterous but rare in the macropterous form, was represented in my collection by one macropterous specimen secured at station 11.

Trepobates pictus H. S. This little water strider was abundant and took first rank among Hemiptera, in numbers of individuals. Nymphs of all stages and adults of the apterous form were taken together. The gregarious habit was very noticeable. Practically none were present on the small pond. With these few and those at station 9 excepted, all were present on absolutely open surfaces of the large pond, though chiefly near shore. This distribution was contrary to that of *G. marginatus*, already noted. It was first obtained the middle of June, but remained common a number of weeks after collections were terminated in October.

A single macropterous specimen was included in the collection. This Drake informed me, is rarely seen. The folded wings extended beyond the abdomen about half the length of the body, but on one side wings were absent, probably having been torn off before coition.

NON-AQUATIC HETEROPTERA.

Halticus citri Ashm.* (*Miridæ*). One specimen of this terrestrial bug was found at station 3, an accidental inhabitant of the water.

Suborder **Homoptera**.

Family *Fulgoridæ*.

Pissonotus brunneus Van. D.† This terrestrial Delphacid was merely accidentally present in the water.

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* Identified by Prof. Herbert Osborn.

† Identified by Prof. Herbert Osborn.

Family *Aphididæ.*

A few species of plant lice, living on aquatic plants may be considered aquatic, in at least as reasonable a sense as the Saldidæ or Collembola are so considered.

Rhopalosiphum nymphææ (Linn.) (?) Many aphids of this genus were found on the duckweed of the small pond, and some at station 5. Most because of immaturity could not be identified to species.

Macrosiphum coreopsidis (Thomas). A smaller number of these aphids were obtained. A few adults made specific identification possible. The species lives on Bidens, and some specimens were actually taken from emergent vegetation near shore. But the species is not reported from any real aquatic plants and must be excluded from an aquatic list.

Order **Thysanoptera.**

Phlœothrips nigra Osb. A very few were taken while collecting on the surface at station 11. But they were only accidentally there and are entirely land forms.

Order **Neuroptera.**

Family *Sialidæ.*

Sialis infumata Newman, was the only representative of the entire order and only a single larva was found in the mud at station 3. Probably some others were present, but it must be listed as rare.

Order **Trichoptera.**

Caddis worms were unusually rare as far as my survey demonstrated. The areas having a deep mud bottom, did not offer a favorable environment, but along shore in the large pond, principally in the stony areas, there would seem to have been a very favorable habitat for certain kinds of caddis larvæ.

Phryganea sp. One larva of this genus, taken somehow without the large characteristic cylindrical case, was found at station 3.

Order **Coleoptera.**

A comparatively large number of beetle species was obtained from Mirror Lake. Some of the species were represented by a considerable number of specimens. Large sized beetles, (except one *Hydrophilus triangularis*) were conspicuously absent.

Many beetle larvæ were obtained, but since the kinds were not recognized in collecting, and the species of a family are

closely similar in a general way, no specific habits or other observations were noted. A separate larval list was hoped for, but the larvæ, given to Dr. Mosher, could not be identified to species or even to genus, but merely to family, with, however, some segregation into presumable generic groups that may assist in future work on beetle larvæ. Figures in the table are of adult beetles entirely.

Family *Carabidæ.*

Elaphrus ruscarius Say, "probably the commonest species along margins of streams, ponds and lakes," (Blatchley '10), was found running on the moist, muddy shore close to the water's edge at station 2, but only a few specimens were seen, all in April. Because of their habitat, members of the genus Elaphrus are properly considered in an aquatic survey, possibly as much so as are the shore bugs, Saldidæ.

Family *Haliplidæ.*

Peltodytes 12-punctatus Say, a rather conspicuous beetle found in the shallow water among algal vegetation, in the small pond, was fairly common.

Peltodytes edentulus Lec., a beetle at first not differentiated from the preceding, was somewhat more numerous than that species.

The characteristic spiny larvæ of this genus were also found not uncommon in the same situations as the adult.

Family *Dytiscidæ.*

No large predaceous diving beetles were present, though there were reports of the one time presence of some form like Dytiscus. Their absence is explicable on examination of various features of the pond.

That depth of water of a pond is related to the presence of a particular kind, or rather particular sized beetle, was found (Needham and Williamson '07) to hold in a pond worked on at Lake Forest, Ill. Dytiscus prevalent in deepest water, then Acilius and then Coptotomus in shallower water, were lacking in Mirror Lake, which was not deep enough; but Laccophilus (the next in their succession, and inhabitating water about a foot in depth) was common in the small pond, where that depth of water prevailed over a large part. Hydroporus they found in still shallower water and Bidesses clung to the very shoreline.

The same distribution for these genera, generally speaking, was evident here.

In the small pond the obstruction of the duckweed covering to convenient surface respiration may have been a factor in the absence of large Dytiscids. But probably more important was the lack of all larger, emergent vegetation, the submerged parts of which are the only places favorable to Dytiscus for egg deposition, (Miall '12).

In the large pond there was the same lack of emergent vegetation. Absence of practically all vegetation was a factor too, for most beetles naturally thrive best in a certain amount of seclusion afforded by vegetation.

Very muddy pond bottoms are very poor habitat for Dytiscidæ (Sherman '13). He says, in fact: "These beetles prefer for their home bodies of comparatively clear water . . . . where the bottom is at least moderately clear and sandy." This would be optimum for many no doubt, but a small amount of mud would not be a deterrent if other conditions were fairly favorable. But in Mirror Lake the mud bottom is sufficiently deep and widespread to act as an inhibiting factor.

In view of these conditions the collection of Dytiscidæ present in the pond was all that could be expected.

Laccophilus maculosus Say. This was one of the common beetles in the pond, though not nearly as abundant as *Tropisternus glaber*. It was about equally numerous in all parts of the small pond and in the spring (station 13).

Laccophilus fasciatus Aube., was not uncommon, but not more than a third as many specimens were taken as of *L. maculosus*. Most specimens were from the shallow pool, station 17.

Desmopachria latissima,* (?). One specimen was obtained at station 11. It should be noted that the species has not been recorded from this region.

Bidessus affinis Say. This was the one species of the genus, which was even fairly common, considering that probably a relatively smaller number were secured and listed in the table, than of larger beetles. While all specimens were noticed practically on the shoreline, more were found at station 3 than at the shallower station 11.

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* Identified as probably this species by Mr. C. W. Leng.

Bidessus lacustris Say. One specimen was taken.

Hydroporus modestus Aube. This fairly common beetle was about as numerous as *L. maculosus.* Practically all were from station 3.

Hydroporus concinnus Lec., was evidently rare as only one specimen was found.

Hydroporus pulcher Lec., was likewise rare with only one specimen found.

Hydroporus dichrous Melsh. probably must also be considered rare, as only two specimens were found.

Copelatus glyphicus Say.* This beetle of which only two specimens were found, was in the same general situation as *Hydroporus.* One of the specimens is piceous and the other slightly reddish.

Family *Gyrinidæ.*

This family was conspicuous by its absence. The writer can say with assurance that none were present during the period collections were made, though there were reports that whirligig beetles were present a few years before. The Lemna covered small pond would be very unfavorable for their gyrations, though the large pond presented no such difficulties. Possibly the absence of favorable aquatic plants for egg deposition was an important factor. Fishes, if they had any effect, would have relatively less upon these than upon other beetles.

Family *Hydrophilidæ.*

The beetles comprising this family were about equal in number of species to the Dytiscidæ, but more numerous in individuals, due chiefly to the abundance of a few common kinds. A considerable number of larvæ were obtained.

Helophorus lineatus Say. This species was found quite common but only at stations 3 and 11. They were usually noticed crawling on submerged vegetation.

Hydrochus inæqualis Lec. This beetle, found in about the same situation as the preceding, must be rated as rare.

Ochthebius nitidus Lec. (?)† Of this beetle also only one specimen was found, so that it must be rated as rare. It was found in vegetation at the very edge of the pond at station 3.

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* Identified by C. W. Leng and H. C. Fall.

† Identified as probably this by Mr. C. W. Leng.

Hydrophilus triangularis Say. Of this species, the largest secured in the survey, only one specimen was found, in the debris off shore at station 15. Hence this, too, must be considered rare here.

Tropisternus nimbatus Say. This was fairly numerous but decidedly less so than *T. glaber*. It was well distributed in the small pond.

Tropisternus glaber Herbst. This was found much more common than its congener just mentioned, and was the most abundant beetle in Mirror Lake. It compared favorably in numbers with the commonest kinds of water striders, except *Trepobates pictus*. As is the case with other really abundant forms, relatively more could have been secured and counted, than the table indicates. They could not be as completely collected nor would be quite as assiduously kept as rare forms.

It was evidently present throughout the small pond and a few were also found in the large. Like *T. nimbatus* it was also found in the pool, station 17. But one place in the small pond, station 12, it was much more abundant than anywhere else. There the mud was not so deep and soft as on most of the bottom, and it had a thin layer of loose, fluffy, brown material, probably the so-called dust-fine detritus, which offered no impediment to the scrambling, swimming combination sort of movement across the bottom which these beetles indulged in.

Philhydrus nebulosus Say. This beetle was found in situations frequented also by *Helophorus*. Like many other beetles it was restricted to the small pond. It was common, and found principally near the north and northeast shore.

Philhydrus ochraceus Melsh. Of this related species only one specimen was found, and it undoubtedly was rare.

Cymbiodyta fimbriata Melsh. This beetle also frequented situations in the small pond like those mentioned above. It was fairly common.

Creniphilus subcupreus Say. This tiny beetle was taken in situations identical with the preceding form. It was very common. The greatest number was obtained from submerged vegetation near shore at station 3.

Family *Parnidæ*.

Dryops lithophilus Germar. This was the one beetle of this family found here. It has been found at Lake Mendota

"on the moist places of the shore" (Muttkowski, '18) and "it may occasionally descend into the water," the assumption evidently being that this form normally lives out of the water as an adult. The single beetle obtained in the present survey was submerged in several inches of water, clinging to the rough bottom of a large, flat stone at station 7. Search failed to disclose any more elsewhere along this pond, or anything which could have been its larval form.

Family *Dascyllidæ.*

Scirtes tibialis Guer. The larva of this beetle, which feeds on duckweed (Kraatz '18) should evidently have found the small pond an ideal habitat. The reason for their scarcity was not clear. They were so few and so scattered that it must be rated as rare.

NON-AQUATIC FAMILIES.

There were furthermore secured, whether on the surface or partly submerged, a number of other beetles of purely terrestrial kinds. They are mentioned here in order to complete the list of species collected, but are not considered among the aquatic forms in the table.

Olibrus consimilis March. (*Phalacridæ*). One adult was taken from on the water surface or overhanging grasses. The larva may have fed on Bidens.

Melanophthalma distinguenda Com.* (?) (*Lathridiidæ*). This specimen was taken close on the shoreline in vegetable debris at station 3.

Family *Chrysomelidæ.*

None of the aquatic members of this family were found; but several terrestrial beetles were there by accident.

Longitarsus testaceus Melch. One of these beetles was taken from aquatic plants near shore.

Chætocnema ectypa Horn† (?). One of these beetles was found in the same situation.

Chalepus dorsalis Thumb. One of these beetles was also found in a similar situation.

Suborder **Rhyncophora.**

Tanysphyrus lemnæ Fab.‡ This was the only aquatic species of snout beetle found here. Only three specimens were secured, from Lemna, but as they would be easily overlooked, they may have been fairly numerous at times.

* Identified by Mr. H. C. Fall.
† Identified by Mr. C. W. Leng.
‡ Identified by Mr. C. W. Leng.

Hypera punctatus Fab. One specimen of this terrestrial snout beetle was accidentally found here.

Phytonomus nigrirostris Fab. Two specimens of this clover pest were also found here, probably having been blown in during a migration over the pond.

Order **Diptera.**

The number of forms of aquatic Diptera found in Mirror Lake, among families other than Chironomidæ, may seem rather small. As far as this is an actual incompleteness in the list, it is due to practical difficulties that existed. No adults were captured or even noticed, so that, unlike for most other orders of insects, no adults were available for identification, except for a very few which happened to breed out in the laboratory.

Family *Tipulidæ.*

Only one larva belonging to this family was found, (at station 3). It was immature and could not be identified even to genus.

Family *Culicidæ.*

Mosquitoes were not common. Probably the situation was not especially favorable for them. Certainly in the large pond, the fishes must have almost prevented the existence of .the wrigglers, but in spite of that a few specimens were found along shore at stations 6, 7 and 9. Dr. Dyar suggested that few species were represented because all were collected late in summer. However, since collecting was done similarly from spring to fall, any other species that might have been present must have been very rare to escape detection completely.

Anopheles was the kind which comprised the largest number of individuals, almost two-thirds of all mosquito material collected. As only larvæ, and a few pupæ were available, the species could not be determined with assurance, though Dr. Dyar wrote that probably it was a mixture of both *Anopheles punctipennis* Say and *Anopheles quadrimaculatus* Say.

Anopheles punctipennis Say*. One adult mosquito of this species was secured just as it had freshly emerged at station 11.

Uranotænia sapphirina O. S. This species was next in individuals. About half as many larvæ were found as of *Anopheles.* The species is not a troublesome one, but Dr. Dyar said he was attacked by one once.

* Identified by Prof. J. S. Hine.

Culex territans Walk. This remaining species of mosquito found was rather scarce. Only a fifth as many larvæ were obtained as for the preceding species. Dr. Dyar wrote me that "it is wholly innocuous, confining its attention to frogs."

Family *Chironomidæ*.

The midges constitute a very important family which was represented by a very considerable number of kinds in Mirror Lake. It must be noted though, that the number of specimens secured large as it is, very likely gives relatively a very inadequate idea of the total midge fauna (as was true likewise of the small Annelid worms) because so much of the mud bottom of the large pond was not at all investigated. As the collections stand the vast majority of the larvæ were secured from the small pond. Undoubtedly midge larvæ formed an important article of food of some Mirror Lake fishes.

A number of bright red larvæ, the well known bloodworms were found in very shallow water, a few in fact in the clear, shallow pool, station 17, in hardly more than an inch of water and not buried in the mud. This bears out the fact, now generally well known (Malloch '15), and treated of especially in work at Lake Mendota (Muttkowski '18) that bloodworms are by no means exclusively bottom dwelling forms, as was so long held.

Adult midges were not seen in the field and unfortunately none reared in the laboratory, though several accidentally emerged from material in an acquarium jar. Pupæ were scarce as compared with larvæ.

Sub-family *Ceratopogoninæ*.

Palpomyia longipennis Lœw. This species was uncommon, probably it should be called scarce. All specimens found were taken in June, at station 3, and all were in the pupal stage.

Palpomyia sp. Other specimens of this genus, all in the larval stage, equal in number to specimens of *P. longipennis*, were found, chiefly at station 11, but were not identifiable to species. Whether they represent one or more than one species cannot be said.

Johannseniella sp. This form was rare beyond any question. Dr. Malloch found but a single larva in all the midge material identified.

Bezzia sp. This form, whether representing one species or more, was scarce, no more numerous than *Palpomyia*. Most specimens were in the pupal stage.

Sub-family *Tanypinæ*.

Tanypus pilosellus Lœw. This species was rare, as only three specimens, (two larvæ and one pupa) were found.

Tanypus monilis Linn. This species was somewhat more numerous than the preceding, but still scarce.

Tanypus dyari Coquillet. This species was common in various parts of the small pond, and was the only one common in the waters of the spring, station 13. Unlike most of its type, and more like many of the genus *Chironomus* it is a bloodworm. Those which lived in the spring, as well as two larvæ found at station 17, furnish good evidence that bloodworms may inhabit well aerated waters. A small number were in the pupal stage.

Tanypus sp. A number of specimens of larvæ of this genus, but of other species unidentifiable specifically, were found in about the same localities as *T. dyari*.

Tanypus sp. B. This species, tentatively so designated by Malloch ('15), was scarce, that is represented by a few specimens.

Sub-family *Chironominæ*.

Chironomus lobiferus Say. This species was common at station 12, but nowhere else. The larvæ are bloodworms. A few of the specimens were pupæ.

Chironomus viridicollis Van der Wulp. This was a common species, particularly in some parts of the small pond. It is one of the common bloodworms. Two were found in the shallow station 17. There was one pupa among the identified specimens.

Chironomus modestus Say. This was a rare species as only two specimens were found, both pupæ.

Chironomus sp. An extremely large number of other specimens of this great genus was found. None of these could be identified to species; unquestionably they represent at least several species as can be logically deduced from examination of figures in the table. It is unfortunate that an extremely abundant or several abundant or common species can not be listed.

Tanytarsus sp. This species was one of the abundant ones, particularly (as far as collections show) in some parts of the small pond. A small number were pupæ, but the vast majority

larvæ. Many were found in the tiny brown cases which *Tanytarsus* builds. Some of these were attached to dead leaves on the bottom, but more of them to stones, particularly those from parts of the large pond. From even the very incomplete records of distribution there, it would seem that unquestionably this was a very abundant species in the large pond.

Cricotopus trifasciatus Panzer. This species was fairly common at best and seemed rather evenly distributed.

Orthocladius sp. This kind, also not identifiable to species, was common, in fact at station 12 it was abundant.

Family *Stratiomyidæ.*

Stratiomyia sp. (?). Only one larva of a soldier fly was found, and that in the vegetation near the surface at station 13. The rarity is surprising. It was far from full grown and could not be fully identified but probably belongs to this genus.

Family *Tabanidæ.*

Chrysops sp. (?) One small, white larva not full grown, belonging to this genus evidently, was found at station 13.

Tabanid sp. Two other very small white larvæ not definitely identifiable to genus, were the only other members of this family found.

A Tabanid egg, mass was found about four inches above the water's surface on an upright emergent broad blade of grass, a foot from shore, in the vicinity of station 8.

Family *Sciomyzidæ.*

Tetanocera plumosa Lœw. This species of fly was of rare occurrence. Two adults bred out in the laboratory October 1, from their short, thick, cylindrical pupal cases which had been collected at station 3, September 20.

Tetanocera umbrarum Linn. This related species, also rare, was represented by only one specimen bred out June 13, from a pupa found at station 3, June 5.

Family *Ephydridæ.*

The minute flies of this family represented here were all bred out in the laboratory. No larvæ were observed or found. They were in the pupal stage when collected.

Notiphila sp. One specimen only of this genus was secured. Hence it was rare. This accidentally bred out from a lot of

material (duckweed, etc.) kept in a battery jar. The pupa was not noticed, and its presence unknown until the emergence.

Hydrellia ischiaca Lœw. This rare species, represented by one adult, bred out under conditions like the preceding.

Parydra breviceps Lœw. This rare species was also represented by one fly bred out as were the preceding.

Philygria opposita Lœw. This kind can be rated as fairly common. While larvæ were not seen, pupæ were numerous and easily found. They were small, oval, of a brownish color, situated in the parenchyma of Lemna leaves, never more than one to a leaf, and centered quite well in the thickest part. The largest number were obtained September 8, and most of those obtained then bred out as flies September 25.

Class Arachnida.

Order **Acarina.**

Water mites were surprisingly rare in Mirror Lake during the period of my collecting. Forms swimming about as conspicuously as they could hardly be overlooked. Conditions in the pond would have seemed favorable enough for mites. Only two individuals were found, both in the small pond, but unfortunately neither specimens nor record of the names have been received from the specialist to whom they were sent for determination.

Order **Araneida.**

Spiders taken in this survey were either on the water's surface, or on vegetation above the surface, or directly on the shore line. At no time did I see a spider dip beneath the surface, though one species included here does that. It is realized that the others, though adapted to moist situations, are not properly regarded as members of an aquatic list.

Dolomedes sexpunctatus Hentz. This can be called a true aquatic spider, for in addition to frequenting moist places and water surfaces, it is known to dive and lurk under floating leaves. It was not common, but specimens were secured from a number of stations.

Glenognatha (Mysmena) bulbifera (Banks). One young specimen of this non-aquatic species was found on aquatic vegetation.

Tetragnatha sp. Members of this genus are not aquatic or even moisture loving (Comstock '12). The few specimens of this genus were found on the water or plants off shore merely by accident.

Lycosa sp. One immature specimen of this genus was found. Although there is one species aquatic in the manner of *D. sexpunctatus* it is not found in this region, and the one taken was undoubtedly a terrestrial one.

Pardosa nigropalpus Emerton. This, an inhabitant of moist places, was found on vegetation above water at a number of stations, but is not to be regarded as aquatic.

Phylum CHORDATA.

Subphylum VERTEBRATA.

It is not known what fishes were in the creek that flowed through the ravine in the early days, nor just what kinds and when fishes were introduced into Mirror Lake, but that some were introduced before the draining of 1895 and several times subsequently is certain. In 1898 (Osburn '99) a spring freshet carried many down to the Olentangy. These points are worthy of note because the fishes, at least to a relatively far greater extent than any other forms, owe their existence in the pond, to artificial introduction. They established themselves firmly, and so altered conditions in the large pond, as to be the dominant organisms there.

In the small pond very few fishes were found. Before connection of the large with it (April, 1919) they were rare there as far as could be ascertained without seining. The union gave opportunity for migration. Though none were observed moving from the large pond, through the narrow channel into the small, some fishes were seen in the latter in the fall of 1919, and decidedly more in the spring of 1920.*

No study of fish food was undertaken. Hence it is only on general principles, but substantiated by deductions from comparisons between the two ponds, that it can be said that the absence of many forms of life in the large pond, could be attributed to the fishes. The large pond was probably overinhabited as far as fishes are concerned. The supply of natural food was added to at times by throwing in broken bread, usually in the vicinity of station 4. The goldfish took to this food more readily than others.

All fishes were collected in two seinings (September 27 and October 4), by Mr. Wickliff and the writer.

* The interesting study of the effects in course of time, of increasing numbers of fishes in the small pond, on the fauna there, can never be made, since the small pond was done away with, June, 1920.

Since none of the fishes could be ascribed to any particular stations, they are entirely omitted from the table.

Family *Siluridæ*.

Ameiurus nebulosus (Le Sueur). The common bull-head or brown bull-head was rare in Mirror Lake. Only one specimen was taken, but it must be noted that since they are bottom dwelling forms, and since the seining along the bottom was very much interfered with by projecting stumps, branches, and stones, others may have escaped.

Ameiurus melas (Rafinesque). The black bull-head was possibly a little less scarce, if the fact that three specimens were taken in the seine as compared with one of the above, is basis for this judgment.

Family *Catostomidæ*.

Catostomus commersonii (Lacepede). The common sucker was also apparently rare. One specimen was secured.

Family *Cyprinidæ*.

Cyprinis carpio Linn. This introduced form, the well known carp was not secured in the seine, but is here included on the basis of positive declaration that it has been taken from the pond, on the fact that we caught glimpses of what unmistakably were carp, and also on the fact that a peculiar specimen was caught which proved to be a true hybrid between a carp and a goldfish.

Carassius auratus (Linn). The goldfish is a common, conspicuous form in the pond, but it certainly did not rank better than third in abundance, although it was the fish most readily seen.

Pimephales notatus (Rafinesque). The blunt-nosed minnow was common but probably somewhat less so than the goldfish.

Abramis crysoleucas (Mitchill). The golden shiner was the most abundant of all fishes in Mirror Lake. Seining disclosed great numbers, quite in excess of the second most numerous species.

Family *Centrarchidæ*.

Apomotis cyanellus (Rafinesque). The green sunfish was also common, in fact very likely the second in abundance of all the fishes.

Class AMPHIBIA.*

Family *Bufonidæ.*

Bufo americanus Le Conte. Toads were scarce here in the breeding season, the only time that adult toads take to water. Some were noticed in spring 1919, but none whatever caught until May, 1920, when a few were observed and one caught, near shore, in the large northwest arm of the large pond. Two others, subsequently captured, were in similar locations. Toads were reported to have been very common about the pond years ago.

Family *Ranidæ.*

Frogs were relatively few in Mirror Lake during the time of this survey, though they also had been much commoner at one time. Very few places along the shoreline offered suitable places of seclusion such as they frequent when out of water.

Rana pipiens Shreber. The common leopard frog could probably not be rated as common here. Numbers were observed in the spring of 1919, but none caught. In fact not until May, 1920, when some more were seen, were two caught and identified. They were taken along the edge of the small pond near station 3, and during a few days, half a dozen more were observed along that pond edge jumping from the grass into the water. One was also observed along the south shore of the large pond and one in the northwest arm of that pond near the bridge.

Rana clamitans Latreille. A large specimen of a male green frog was caught May 15, 1920, while it was squatting at the water's edge on a depressed grassy area, along the southeast shore of the large pond. This species was no doubt scarce.

Class REPTILIA.

Reptiles were scarce in Mirror Lake. Possibly some other form than the two noticed, was present for somewhat as in the case of Amphibia, their habits of seclusion would make them inconspicuous.

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* Amphibia, since not closely connected with definite stations, are omitted from the Table.

Order **Chelonia.**

Family *Testudinidæ.*

Chrysemys marginata (Agassiz). The western painted terrapin was the only member of the order found here. A small specimen was taken at station 3 in May. One somewhat larger was seen exposed for a short time at the surface and then submerged out of sight beneath the duckweed. A still smaller one was taken in the northwest part of the large pond, north of the bridge, May, 1920.

Order **Ophidia.**

Family *Colubridæ.*

Natrix (Tropidonotus) fasciata sipedon (Linn). The common water snake was found to be rare here. One young specimen (7 inches long) was caught, and was the only one noticed. It was swimming close to shore near station 3, May, 1920.

Class Mammalia.

Order **Rodentia.**

Fiber zibethicus (Linn). The muskrat was the only one of the true aquatic mammals present here, and it was rare. There would appear to have been a dearth of appropriate situations and materials for home building, although the shallowness of the water and the possibility of constructing burrows under overhanging banks which existed at some places probably were favorable conditions. Whether there was only one or two, or a few more present could not be ascertained. One was seen to swim straight across a portion of the east end of the large pond, and then submerged. Efforts to locate it were futile. On another occasion, a pathway straight through duckweed on the small pond, showed that a muskrat had traversed there.

Mus norweg'cus Erxleben. The large brown rat would also very likely have been an inhabitant of burrows underneath overhanging banks. It was reported (Stehle '20) as present, and the writer saw one take to the water and disappear under the banks east of station 6, but no trace of it could be subsequently found.

TABLE I.

NUMBERS OF SPECIMENS OF THE VARIOUS AQUATIC SPECIES SECURED AT THE VARIOUS STATIONS.

Name of Species	Station Numbers: Small Pond							Large Pond										Total
	1	11	17	13	2	12	3	4	14	15	5	6	7	16	8	9	10	
Spongilla fragilis (colony)														1				1
Hydra viridissima	2																	2
Hydra oligactis	7	3					1											11
Planaria gonocephala													3					3
Paragordius varius					1													1
Chaetogaster sp.	5	1																6
Slavina appendiculata (?)	10	5			1		4											20
Nais sp.	10	71				10	17									1		109
Dero limosa (?)		2				4	3											9
Limnodrilus sp.	1	54			6	33	1				1							96
Tubifex multisetosus	6	15		1	2	18	6											48
Tubifex tubifex (?)		8				2	1											11
Aulodrilus pluriseta (?)		2																2
Glossiphonia stagnalis	6	41			3	7	15	2			1							75
Glossiphonia fusca		1																1
Placobdella rugosa						1												1
Herpobdella punctata	18				11	1												30
Lymnaea obrussa	1						1											2
Lymnaea humilis & var.			6		1	2	3										1	13
Lymnaea parva (?)																		1
Physa gyrina	7	2		1	1	2	7									1		20
Physa heterostropha	16	5	2	2	4	11	29											69
Physa integra	2			1			3										3	9
Anodonta grandis															55			55
Musculium transversum					1	8	5											14
Simocephalus serrulatus							20								1			21
Simocephalus vetulus	50	3			4		10									1		68
Cyclops bicuspidatus	35																	35
Cyclops albidus	5	1					1											7
Cyclops serrulatus	12	10																22
Asellus communis	5			11	5		3											24
Asellus intermedius	8	5		25	2	3	16	1				1						61
Eucrangonyx gracilis	3						3											6
Cambarus rusticus		2					2											4
Cambarus bartoni robustus										1								1
Sminthurides aquaticus							1											1

TABLE I—(Continued).

Name of Species	Station Numbers																	Total
	Small Pond							Large Pond										
	1	11	17	13	2	12	3	1	11	15	5	6	7	16	8	9	10	
Isotoma palustris		1				1		1										3
Podura aquatica		3		5	1		3			2	6	14	14					51
Hexagenia sp.																2		2
Heptagenia sp.													1					1
Caenis sp.		1						4		1	1		1			3	1	12
Callibaetis sp.		8	12		1	8	11						1					41
Argia violacea							4											4
Enallagma antennatum	2	6	2	1		1	1					1			1			15
Enallagma exsulans														1				1
Ischnura posita	2		1		3	2		2	1				1					12
Ischnura verticalis	2	2			3	1	1			2	1							12
Libellula pulchella	1				4	2	4									1		12
Plathemis lydia				1		2												3
Sympetrum rubicundulum													1					1
Pachydiplax longipennis										1								1
Arctocorixa alternata			8															8
Arctocorixa scabra	9	4		13		2	3											31
Corixa verticalis		5	10	3			12			5				1		4		40
Notonecta variabilis			1															1
Ranatra americana									1	2								3
Belostoma fluminea		1					1		1	1								4
Micranthia humilis												1						1
Mesovelia mulsanti		15	1	1		14	11		6	5		4	1			4		62
Merragata brunnea										1								1
Microvelia borealis		3	12							1		1	1			1		19
Gerris remiges							1											1
Gerris marginatus		25		3	2	4	35			1	1				1	5		77
Tenagogonus hesione		1																1
Trepobates pictus		2					2	4	2	6	55	6	47	1	4	30		159
Rhopalosiphum nymphaeae (?)		25				8	1				1							36
Sialis infumata							1											1
Phryganea sp.							1											1
Elaphrus ruscarius					2													2
Peltodytes 12-punctatus		2	5	1			3									1		12
Peltodytes edentulus		5	5	1		2	3									2		18
Laccophilus maculosus	2	2	3	6		5	5			1								24
Laccophilus fasciatus		2	7			1												10
Desmopachria latissima		1																1

TABLE I—(Continued).

Name of Species	Station Numbers																	Total
	Small Pond							Large Pond										
	1	11	17	13	2	12	3	4	14	15	5	6	7	16	8	9	10	
Bidessus affinis		1	1				7									2		11
Bidessus lacustris							1											1
Hydroporus concinnus																		1
Hydroporus pulcher						1												1
Hydroporus modestus				1		2	20											23
Hydroporus dichrous		1					3											4
Copelatus glyphicus							2											2
Helophorus lineatus		9				1	13					1						24
Hydrochus inaequalis							1											1
Ochthebius nitidus (?)							1											1
Hydrophilus triangularis										1								1
Tropisternus nimbatus		3	1			1	4			1								10
Tropisternus glaber	3	19	3	4		37	8			1					2			77
Philhydrus nebulosus	2	12				9	2											25
Philhydrus ochraceus		1																1
Cymbiodyta fimbriata		2				7	2											11
Creniphilus subcupreus		6				5	18											29
Dryops lithophilus													1					1
Scirtes tibialis (larva)							2	1							1			4
Tanysphyrus lemnae		2					1											3
Tipulid larva							1											1
Culex territans				2			2											4
Uranotaenia sapphirina		5	1	5		1	9											21
Anopheles punctipennis		1																1
Anopheles sp.		15	4	10			20	1				2	2		1	1		56
Palpomyia longipennis							10											10
Palpomyia sp.		10					2											12
Johannseniella sp.		1																1
Bezzia sp.		6					6								2			14
Tanypus pilosellus		1					2											3
Tanypus monilis	1	7			1		1											10
Tanypus dyari	1	12	2	15	2	4	11											47
Tanypus sp.	1	5				7	1											14
Tanypus sp. B.		3				5												8
Chironomus lobiferus		4				18	4											26
Chironomus viridicollis		30	2	5			16										1	54
Chironomus modestus							2											2
Chironomus sp.	5	81			5	95	74					5	4			33		302

TABLE I—(Continued).

Name of Species	Station Numbers																	Total
	Small Pond							Large Pond										
	1	11	17	13	2	12	3	4	14	15	5	6	7	16	8	9	10	
Tanytarsus sp.	1	16				8	33	3	5		7	8				14	5	100
Cricotopus trifasciatus	8	3				13	11									7	1	43
Orthocladius sp.	3	18				43	4				1					4		73
Stratiomyia (larva)				1														1
Chrysops sp. (larva)				1														1
Tabanid larva					1							1						2
Tetanocera plumosa							2											2
Tetanocera umbrarum							1											1
Notiphila sp.																1		1
Hydrellia ischiaca				1														1
Paraydra breviceps						1												1
Philygria opposita						4	3					14						21
Dolomedes sexpunctatus							1				1	1	2			1		6
Chrysemys marginatus						2										1		3
Natrix fasciata sipedon							1											1

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EXPLANATION OF PLATE II.

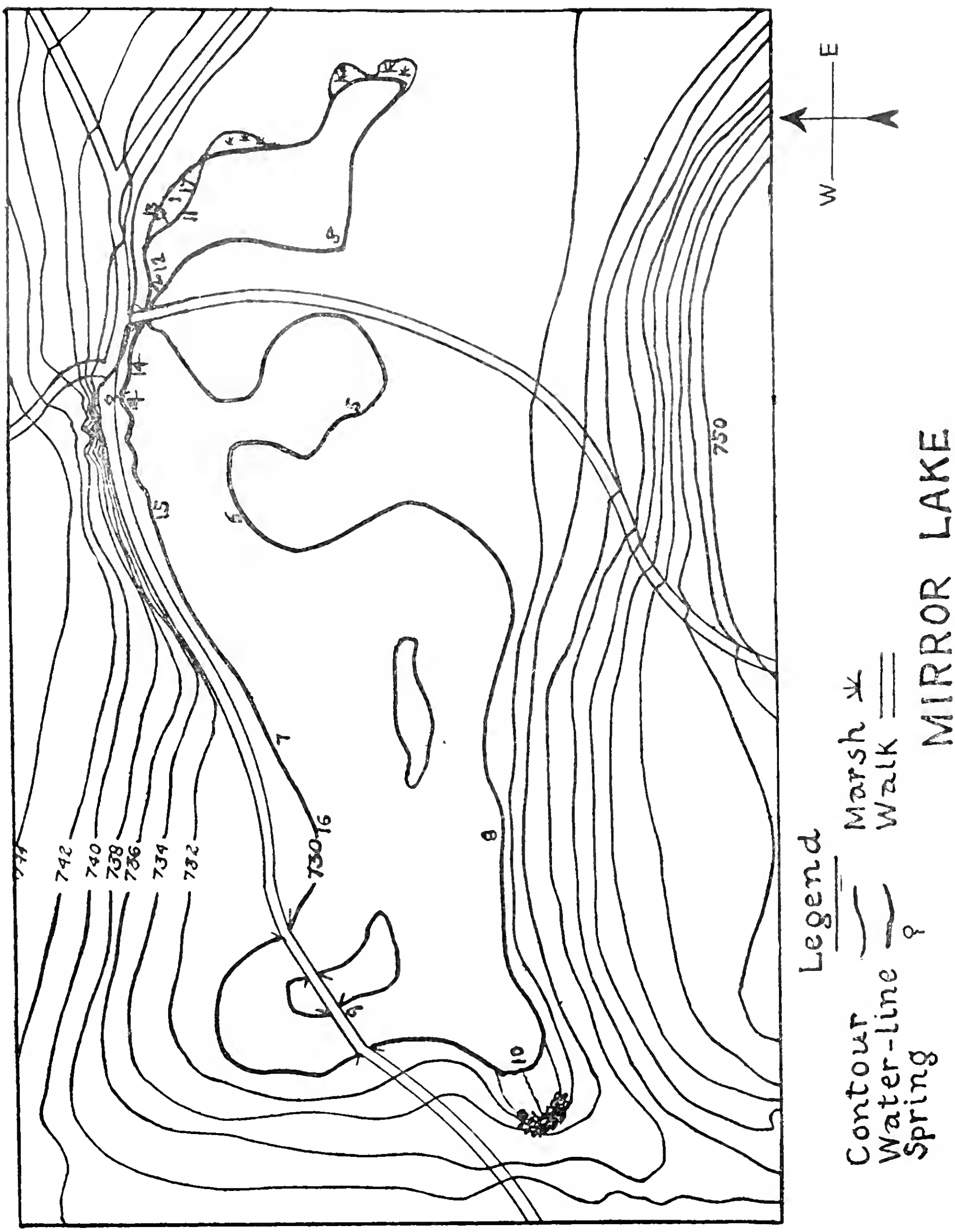
(Mirror Lake views before the alterations made June, 1920).

Fig. 1. The large pond; taken from the west end (near station 10) looking eastward; island in center; portion east of line crossing at about region of stations 6 and 15, not visible.

Fig. 2. The large pond; the east end, looking eastward from a point on north shore midway between stations 7 and 15; stations 4 and 14 at left; station 6 at right; connection with small pond under walk (white line) to left of center.

Fig. 3. The small pond; looking in northwest direction from southeast end; station 3, darker area directly across at left of center; station 12 upper right end of pond; duckweed (showing white) covering most of water. August, 1920.

Fig. 4. The small pond; looking across at east shore, north half; station 11 occupying most of foreground; station 13, the spring, open spot on shore to left of center. August, 1920.


MIRROR LAKE
Legend
Contour
Water-line
Spring
Marsh
Walk
W
E
750
742
740
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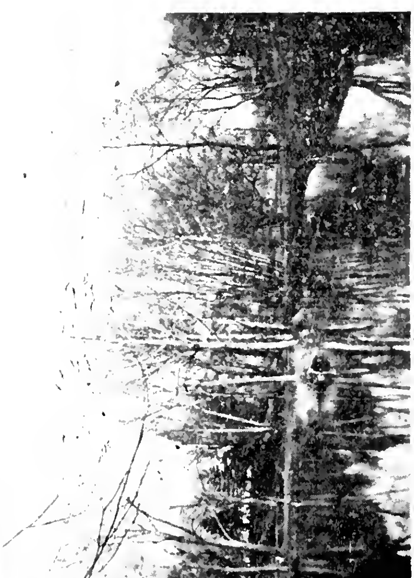
734
732
730



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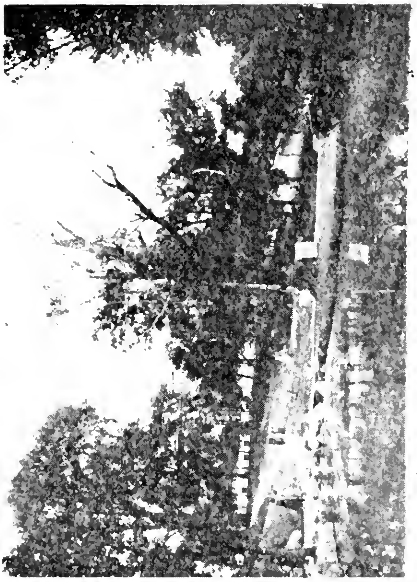

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REVERSAL OF THE SEXUAL STATE IN CERTAIN TYPES OF MONECIOUS INFLORESCENCES.*

John H. Schaffner.

The sporophyte of those higher plants which have an antithetic alternation of generations is usually described by morphologists as being nonsexual. This means that the sporophyte generation does not produce gametes directly but spores which develop into the gametophyte generation by ordinary cell division, never showing the property of sexual attraction. It is evident that the term "nonsexual" cannot imply that there can be no morphological difference due to a difference of sexual state in various parts of the sporophyte; for there is such a difference in all of the living heterosporous plants. It would be manifestly unadvisable to ascribe the dimorphism of stamens and carpels, for example, to any other properties or qualities than sexual states of the same fundamental nature as those which produce sexual dimorphism in gametophytes and gametes.

If we consider the sporophyte as "nonsexual" because it does not produce gametes directly but nonsexual spores, we may, nevertheless, consider its cells as all potentially sexual since they give rise farther on in the cell lineage to sexual individuals producing gametes. All homosporous sporophytes, therefore, including those of Liverworts, Mosses, Hornworts, Ferns, Horsetails, and Lycopods, are only potentially sexual and are in a neutral state in respect to sex during their entire life history. No sexual state is ever set up directly in their cells until after the stage of sporogenesis is reached, except in such abnormal species where apospory is present. Every such sporophyte is essentially similar in its morphology to every other sporophyte of the same species. In other words, there is absolutely no sexual dimorphism apparent in any part of the

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body. The Bryophytes and Homosporous Pteridophytes may, therefore, be defined as: Those higher plants which normally show no indication of sexual dimorphism in the sporophyte either in respect to structure or function.

On the other hand, in all of the living heterosporous plants, as intimated above, including the Water-ferns, Quillworts, Selaginellas, Cycads, Ginkgo, Gnetums, Monocotyls, and Dicotyls, there is sexual dimorphism to a greater or less degree and extent in the sporophyte tissues. In the lowest types, this dimorphism does not extend beyond the sporangium and its stalk, but in the extreme diecious species sexual dimorphism may be present to a greater or less degree thruout practically the entire plant. The living heterosporous plants may, therefore, be defined as: Those plants whose sporophytes always show sexual dimorphism to a greater or less extent, at least in the tissues of the sporangia or sporophylls.

Because of the appearance of sexual dimorphism in the vegetative tissues of heterosporous sporophytes, it becomes evident that there must be reversals of sexual states in these tissues, either from a neutral state to one or the other sexual state or in some cases from one sexual state to the other or to a neutral state again during the growth of the tissues. The writer has been making observations for several years on a considerable number of monecious species of the type in which the inflorescence is completely staminate in one part and carpellate in the other. In the present paper only such cases are considered which show a general reversal in the flower cluster from the male state to the female or vice versa. A considerable number of common species show a general distribution or commingling of staminate and carpellate flowers which might also be studied to advantage.

In the cases at hand it becomes self-evident that the growing meristem of the inflorescence axis is either in one sexual state and then passes thru a neutral condition during its growth to the opposite sexual state or that it is constantly in a neutral state but the lateral structures derived from it are thrown into the male or female state depending on the functional activity of the cells at the time. The change from carpellate structures in the lower part of the inflorescence to staminate structures above is apparently much more common than the opposite condition, from staminate to carpellate, notwithstanding the

fact that in the Anthophyta bisporangiate flowers have their stamens below and their carpels above. The reason for this may be that in the comparatively long axis of the inflorescence the outer, later end may usually be in a much less favorable or at least different condition functionally than the lower part, while in the evolution of the flower, the two parts of the flower axis may be more alike or the upper part even better placed for favorable metabolism than the lower part. At least there are strobili and flowers which plainly show a crowding on the lower part of the axis.

Below are given lists of common plants in which a complete change from one sexual state to the other takes place in the inflorescence. Besides the examples of a change from carpellate to staminate or from staminate to carpellate, a few special cases are also cataloged, the most significant of which appear to the writer to be the inflorescences that change from bisporangiate flowers below to staminate flowers above.

INFLORESCENCES WHICH ARE CARPELLATE BELOW AND STAMINATE ABOVE.

Sagittaria latifolia Willd.
Sagittaria rigida Pursh.
And other species of *Sagittaria*.
Sparganium eurycarpum Engelm.
And other species of *Sparganium*.
Typha latifolia L.
Typha angustifolia L.
Peltandra virginica (L.) Kunth.
Zantedeschia aethiopica Spreng.
Arisaema dracontium (L.) Schott.
Monecious individuals.
Cymophyllus fraseri (Andr.) Mack.
Carex nardina Fries.
Carex capitata L.
Carex gynocrates Wormsk.
Carex chordorrhiza Ehrh.
Carex arenaria L.
Carex leavenworthii Dew.
Carex cephaloidea Dew.
Carex jamesii Schw.
Carex leptalea Wahl.
Carex rupestris All.
Carex lacustris Willd. Carpellate spikelets below, staminate above.
Many other species of Carex.
Carex lupulina Muhl. Several carpellate spikelets below; one staminate spikelet above.
Other species of Carex.
Zizaniopsis miliacea (Mx.) D. & A.
Tripsacum dactyloides L.
Musa sapientum L.
Stillingia sylvatica L.
Cnidoscolus stimulosus (Mx.) Engelm. and Gr.
Acalypha virginica L.
Tragia urens L.
Tragia nepetaefolia Cav.
Tragia ramosa Torr.
Tragia macrocarpa Willd.
Ditaxis mercurialina (Nutt.) Coult.
Croton glandulosus L.
Pachysandra procumbens Mx.
Myriophyllum spicatum L.
Myriophyllum heterophyllum Mx.
And other species of *Myriophyllum*.
Ambrosia trifida L.
And other species of Ambrosia.
Gaertneria acanthicarpa (Hook.) Britt.
Gaertneria discolor (Nutt.) Ktz.
Gaertneria tomentosa (Gr.) Ktz.
Xanthium spinosum L.
Xanthium pennsylvanicum L.
Polymnia uvedalia L.
Polymnia canadensis L.
Silphium perfoliatum L.
Silphium integrifolium Mx.
Other species of Silphium.
Artemisia caudata Mx.
And some other species of Artemisia.

INFLORESCENCES WHICH ARE CARPELLATE ABOVE AND STAMINATE BELOW.

Carex norvegica Willd.
Carex heleonastes Ehrh.
Carex glareosa Wahl.
Carex canescens L.
Carex brunnescens (Pers.) Poir.
Carex scoparia Schk.
Carex cristatella Britt.
Carex bicknellii Britt.
Carex praticola Rydb.
Carex davisii S. & T.
Zizania aquatica L.
Ricinus communis L.
Acalypha ostryaefolia Ridd.
Salix amygdaloides Anders. Abnormal monecious individuals.

SPECIAL CASES.

Lophotocarpus calycinus (Engelm.) J. G. Smith.
And other species of Lophotocarpus. Flowers in the lower part of the inflorescence bisporangiate, in the upper staminate.

Arisaema dracontium (L.) Schott.
There are staminate individuals and monecious individuals. The monecious are staminate above and carpellate below.

Leptamnium virginianum (L.) Raf.
Lower flowers cleistogemous and fertile; upper flowers perfect and open, but mostly not producing seed.

Specularia perfoliata (L.) A. DC.
And other species of Specularia.
Lower flowers cleistogamous and carpellate; upper flowers perfect.

Carex bromoides Schk.
Some spikelets have both basal and terminal staminate flowers with the carpellate flowers in between.

Viola papilionacea Pursh.
And numerous other species of Viola have perfect open flowers followed later in the season by cleistogamous, fertile flowers with only the two appendaged stamens developed.

Zea mays L.
Occasionally abnormal ears are carpellate below, staminate in the middle, and then carpellate again at the outer end. Also staminate inflorescence may have the main axis with carpellate spikelets in the middle and staminate spikelets below and above.

STUDY OF SPECIAL SPECIES.

Since there is a functional change during the transition from the one state to the other in the type of inflorescence under discussion, it was thought that an examination of the transition zone would show some interesting peculiarities. Consequently, a rather detailed study has been made of a selected number of species in order to determine the character of the morphological expressions on the transition zone between the staminate and carpellate parts, i. e., on the region between the tissues which are in a male state and those which are in a female state.

Ricinus communis L. Castor-oil plant.

The inflorescence of Ricinus is a panicle with staminate flowers below and carpellate flowers above. Typically the transition from one type of flower to the other is quite abrupt. There are numerous examples, however, in which a flower on the transition zone is bisporangiate. See Fig. 1. In such a case it is evident that the incipient flower bud is in a neutral condition to a rather late stage. Then the incipient tissue at the base of the flower bud goes into the male state and as a result typical branched stamens develop. The tip of the bud passes into the female state and gives rise to the normal three-carpelled gynecium. In the staminate flowers immediately below, the male state must be established at the very inception of the flower bud or even earlier and thus the entire bud is in the male state which inhibits completely the development of a gynecium. On the other hand, in the carpellate flowers above the transition zone, the female state is established at the inception of the flower bud and this condition inhibits all development of an andrecium.

Peltandra virginica (L.) Kunth. Green Arrow-arum.

This plant has a spadix which is carpellate below and staminate above. The carpellate flowers have prominent vestigial stamens while the staminate flowers show no evident vestige of a gynecium. The transition from the carpellate part of the spadix to the staminate is sometimes abrupt, but very frequently there is a transition zone of some width, in which case this area is characterized by flowers showing all gradations from normal gynecia to the merest vestige of a gynecium; and finally, of course, the flowers are purely staminate. Figs. 2, 3 and 4, represent such a series. Fig. 2 is a normal carpellate flower; Fig. 3, a flower with reduced gynecium, the stamens being still vestigial; Fig. 4, a flower from near the staminate side of the zone with a slender, pointed vestige of a gynecium and the stamens still somewhat imperfect. The next flower above was a normal staminate flower with no vestige of the gynecium.

Typha latifolia L. Broad-leaf Cat-tail.

In Typha the carpellate part of the inflorescence is below and the staminate above. The two parts are usually contiguous in the broad-leaf species and usually some distance apart in

the narrow-leaf species. A specimen was looked for in which there would be an invasion of one area into the other. Such a specimen was readily found. The one studied had a patch of staminate flowers on one side at the top of the carpellate part of the inflorecsence. On the transition zone flowers of an intermediate nature were common. Fig. 5 represents a typical carpellate flower with its prominent stigma and Fig. 6 represents a typical staminate flower consisting of one stamen. The staminate flowers have from one to six stamens. Fig. 7 represents one of the intermediate flowers. The ovulary is undeveloped but there is a nearly normal stigma at the top and two imperfect microsporangia with spore tetrads. Fig. 8 is a double structure, the one part being a nearly perfect anther while the other has a microsporangium on one side and an imperfect half stigma on the other.

Arisæma triphyllum (L.) Torr. Jack-in-the-pulpit.

A certain per cent of the inflorescences of Jack-in-the-pulpit are of an intermediate nature being staminate in one part and carpellate in another. The "spotting" of the staminate and carpellate areas is quite diverse. Sometimes the spadix is carpellate below and staminate above; sometimes, the reverse; sometimes, there are irregular spots like in a crazy patch quilt. Such inflorescences are quite favorable objects for the study of the influence of contiguous tissues with male and female states, especially if the two tissues involve parts of the same flower. The flowers of Arisæma have very definite positions in spirals, determined by the fundamental heredity, and it frequently happens that the transition line or zone between two tissues of opposite sexual state passes directly thru a flower, in which case the structure is carpellate on one side and staminate on the other. The incept of the flower is organized as a unit in spite of the fact that the cells on the one side are in a female state and on the other in a male state or at least in a condition leading to these states. The hereditary factors which determine the position and unity of the flower have no direct relation to the extent or limits of the sexual states. Sometimes, there is an appreciable neutral zone between the typical staminate and carpellate areas, in which case any flower that falls largely or entirely within this neutral strip will be vestigial or develop as an abnormal vegetative structure.

Fig. 9 represents a carpellate flower with its edge extending into a staminate area. This gynecium is nearly normal but it has an anther growing out of the side near the top. Fig. 10 represents a similar gynecium with two anthers growing out of the side toward the staminate patch. Fig. 11 is a normal gynecium with a large anther at one side near the top. In Fig. 12, a nearly normal stamen is growing out from near the base of the gynecium. Fig. 13 represents a gynecium exactly on the transition line. The ovulary is quite normally shaped. On the side toward the carpellate area there is a normal V-shaped stigmatic surface. In the middle are present a number of abnormal outgrowths, one with a small stigmatic tip. On the side next to the staminate area is one stamen with a double anther and two separate anthers, one of them very close to the stigma. Fig. 14 represents a reduced flower from the transition zone with three anthers growing from the side of the ovulary. Fig. 15 represents a flower so situated that the transition line passes through its center. On the one side is an imperfect ovulary with a two-forked stigma, on the other side of a central depression are two anthers. Fig. 16 represents a small area of flowers carpellate on one side and staminate on the other. On the transition zone there is an imperfect ovulary representing about one-third of a normal structure while two-thirds is transformed into a staminate tissue bearing two anthers. Sometimes the transition zone appears to contain a rather broad strip of neutral tissue. Such a condition is shown in Fig. 17. One ovulary, somewhat to the carpellate side of the zone, is considerably reduced in size. The next one is very rudimentary while the third has developed into a long-horn-like vegetative structure similar to the vegetative projections frequently developed on the neutral part of the spadix above the carpellate part.

Myriophyllum heterophyllum Mx. Variant-leaf Water-Milfoil.

The water-milfoil has a spike which passes rather gradually from the female state below to the male state above. The carpellate flowers have large stigmas and minute petals and stamen vestiges. The staminate flowers above have small, vestigial stigmas, large, normal stamens, and large petals. The small and large petals are sex-limited characters. The carpellate flowers also have somewhat larger sepals than the staminate

and the staminate flowers have vestigial ovules. There is every gradation of size and completeness between the two extremes across the transition zone. Figs. 18–24 represent such a succession. Fig. 18 is a typical carpellate flower. In Fig. 19 the petals and stamens are considerably larger while the stigmas are reduced. Fig. 20 represents a stage somewhat nearer the carpellate flower altho the petals are larger. One of the stamens is considerably more developed than the others while the stigmas are nearly normal. In Fig. 21 the structures are nearly all intermediate between the two extremes. In Fig. 22 the stamens are prominent tho still imperfect, the petals approach the staminate type, while the stigmas are much reduced. Fig. 23 represents a normal staminate flower above the transition zone, just before the petals unfold and the filaments elongate. The petals have been removed. One of them is represented in Fig. 24.

Zizania aquatica L. Wild Rice.

The panicle of the wild rice is staminate below and carpellate above. If one examines a branch on or near the transition zone of the main axis, he finds first staminate spikelets, then bisporangiate spikelets, often with perfect andrecia and gynecia and finally at the tip normal carpellate spikelets. The lemmas of the staminate spikelets are awnless while those of the carpellate ones are long-awned. On the transition zone, one can find spikelets with awns of every conceivable intermediate length. The awn of the wild rice is a prominent sex-limited character and its length depends on the intensity of the staminate or carpellate state present, or on the earliness or lateness of the time that the sexual state is developed in the spikelet or its glumes. Fig. 25 represents a staminate flower with all the stamens removed except one. The gynecium is quite vestigial because of the presence of the male condition. Fig. 26 represents the same gynecium highly magnified. The third vestigial stigma is considerably smaller than the other two. This stigma is vestigial in a phylogenetic sense while the other two are ontogenetically vestigial on account of the inhibitory action of the male state in the flower. Fig. 27 represents a bisporangiate flower from the transition zone. Only one stamen is represented. The gnyecium, not quite mature, is normal with typical ovulary and stigmas. Fig. 28 represents the gynecium and

andrecium of a mature carpellate flower. The stamens are vestigial because of the changed sexual state. Figs. 29–34 represent a series of spikelets from the staminate part of a branch to the carpellate part. The length of the awn is determined in the vegetative tissues, depending on the nature of the sexual state present. Sex limited characters of this sort are not due to presence or absence of factors but sexual states present in the tissues during their development.

Salix amygdaloides And. Peach-leaf Willow.

Several years ago the writer discovered a number of remarkable trees of this species in a grove in Kansas.* The trees in question have monecious catkins, being staminate in the lower part and carpellate in the upper, with a wide transition zone from the one sexual state to the other. As was to be expected under such conditions, the transition part of the axis is covered with all sorts of abnormal flowers. Figs. 35–51 represent some of the gradations and confusions of sexual expressions to be observed. They exhibit something of the remarkable patchwork of small areas of tissues in different sexual states to be observed in many monecious infloresceness. They show that not only is the sexual state reversed from the lower part of the axis of the catkin to the upper part but that an organ may be practically intermediate in morphological expression because the tissue is "spotted" in respect to the sexual state. An ovulary may be normally developed in respect to the character of its wall or some of the stigmas and may even have normal ovules which develop into seeds and, at the same time, have certain areas developed into microsporangia. Or a stamen with normal microsporangia may have an imperfect stigma or its stalk may be more or less carpellate in nature, taking on some of the characters of an ovulary. The meristematic tissue in the neutral zone was either entirely neutral, in respect to sex, or the sexual state was so weakly developed that reversals were easily brought about. In either case the incepts of the floral structures were developing according to the activity of the hereditary factors present, determining the position, unity, diversity, and other characters of the parts, but the change of the sexual state in local cells and groups of cells of these incip-

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* Schaffner, John H. The Nature of the Diecious Condition in Morus alba and Salix amygdaloides. Ohio Journal of Science; 19:409-416. 1919.

ient structures caused staminate and carpellate characters to appear in a mosaic. It is even possible that there are no distinct, general staminate and carpellate factors but common dimorphic factors which produce one type of characters under a female state and another type under a male state. Whatever distinctive factors for carpellate or staminate characters are present are rendered latent or active, depending on the sexual state of the cells involved at the time of development.

Altho sexual states must be regarded as fundamental to the living cell, probably, of a chemical or physical nature and brought about by an intimate change of materials held in the meshes of the living structure or some change in the living material itself, it is probable that the reactions of the complex hereditary factors to sexual states is essentially similar to other dimorphic reactions; as for example, the difference in characters caused by youth and senility, by light and darkness, or some of the striking differences accompanying aquatic and aerial environments characteristic of certain species of water plants.

The figures from Salix may be briefly explained as follows: Fig. 35 represents a normal staminate flower with five stamens from the lower part of the catkin. Fig. 36 represents a normal carpellate flower with three stigmas and Fig. 37 one with stigmas from the upper part of the catkin. Fig. 38 is a flower from the lower part of the transition zone with two perfect stamens branching off from the lower part of the ovulary and an abnormal stamen coming out of its side. The stalked anthers are the normal yellow after being preserved in alcohol while the sessile anther from the side of the ovulary is of a brownish color partaking of the nature of the ovulary wall. Fig. 39 represents a bisporangiate flower with stamens developed at various levels from the ovulary wall. Fig. 40 shows one stamen with an enlarged filament having carpellate characteristics and an imperfect stigma. This flower was at the base of the transition zone next to the normal staminate flowers. Fig. 41 shows an interesting bisporangiate flower with two stamens and a microsporangium developed near the top of the ovulary. The stigma just above this microsporangium is much reduced because of the influence of the tissue in the male state immediately below. The other stigma is normal. Fig. 42 represents a bisporangiate flower with one stamen and a microsporangium from the side

of the ovulary wall above. Fig. 43 shows a similar flower with two stamens below and three microsporangia on the ovulary below the imperfect stigmas. Fig. 44 shows an abnormal flower containing a complex of abnormal stamens, ovulary and stigmas. Figs. 45, 46, and 47, are three other similar types from the transition zone. Fig. 48 represents an abnormal carpellate flower with two sessile anthers and an imperfect stigma. Fig. 49 represents a carpellate flower from the top of the transition zone with a nearly normal ovulary but with two small microsporangia from its wall near the top and with three imperfect stigmas. Fig. 50 represents a nearly normal gynecium but from the side of the ovulary a short-stalked stamen, an imperfect stigma, and a very small stamen have developed. Finally, Fig. 51 shows a partly matured ovulary with seeds and the remains of two anthers. It will be noted that the side of the ovulary from which the anthers developed failed to enlarge while the opposite side passed thru the normal growth of an ovulary in which seeds are maturing.

What can be said to a series of facts as recounted above? Hundreds, even thousands of pictures might be published each one showing a distinct type or peculiarity of sexual expression with the accompanying confusion of staminate and carpellate characters. The examples given show one thing conclusively, that sexuality is something fundamentally different from the ordinary Mendelian hereditary factors, and that sex determination and sex reversal take place in small contiguous areas of vegetative cells with absolutely no relation to segregation or association of Mendelian factors. It behooves those botanists who have been carried away into an ultra-simple explanation of sexual phenomena as being due to the segregation and association of homozygous or heterozygous sex factors or homozygous or heterozygous "sex chromosomes" to reconsider the foundations of their faith and adopt an explanation that will, at least, not contradict the great body of complex phenomena of sexual expressions as they actually occur in plants, and in animals also.

CONCLUSIONS.

The foregoing study shows that in plants sex is due to a state or condition; that in the same general tissue system some cells may be in the female state (+), some in the male state (−),

and some in the neutral state; and that each state is quantitative, exhibiting a greater or less degree of intensity. The sexual state has no direct relation whatever to a segregation or association of chromosomes with a possible homozygous or heterozygous relation to hypothetical sex factors. Such an hypothesis is not only impossible but to the writer it would appear as the height of absurdity to even suggest it as an explanation of the phenomena described. It is plain to any one familiar with sexuality in the plant kingdom in general, that sexual states usually arise during the vegetative growth of the cells or tissues, that they must in most cases, at least, come from neutral states, and that they are often easily reversible, the female to the male or the male to the female. The phenomena of maleness, femaleness, and neutrality of cells, tissues, organs, or entire individuals do not come under the category of hereditary units or factors in the ordinary sense and are certainly not Mendelian, altho when their determination coincides with fertilization or reduction they may have a superficial resemblance to normal Mendelian phenomena. Sexuality will probably find its final explanation in relation to the somewhat similar physical and chemical phenomena, as electricity, magnetism, ionization, electrons, and the like.

It is remarkable that the opposite types of sexual states may arise in small contiguous areas of a common vegetative tissue; and that if the line of demarkation passes thru a unit structure, like the flower of Arisæma triphyllum, the one side should be staminate and the other side carpellate. The very organs in which the factors become active for the expression of sexual characters may thus become tissue mosaics in respect to these characters. Since maleness, femaleness, and neutrality are states plainly reversible during vegetative growth under different metabolic levels of the tissues or organs of the individual, it becomes evident that sex can not only be controlled but that it can be changed in any organism of indeterminate growth or in any part of an organism of determinate growth which possesses tissues that reproduce or regenerate themselves. It is even possible that cells which have completed their ontogeny might be reversed in sexual state, altho such reversal could probably only show itself functionally by the production of certain chemical bodies and not morphologically.

Columbus, Ohio, Dec. 6, 1920.

EXPLANATION OF PLATES I AND II.

All the drawings were originally magnified and then reduced in the reproduction of the plates.

Ricinus communis L.

Fig. 1. Bisporangiate flower from the transition zone between the staminate and carpellate parts of the inflorescence.

Peltandra virginica (L.) Kunth.

Fig. 2. A normal carpellate flower showing the character of the gynecium and the prominent vestigial stamens.

Fig. 3. A flower from the transition zone showing the gynecium greatly reduced.

Fig. 4. A flower from the transition zone, near the staminate part of the inflorescence, showing a small vestigial gynecium with an elongated tip and 4 vestigial stamens. The normal staminate flowers have no vestige of carpels.

Typha latifolia L.

Fig. 5. Normal carpellate flower, showing the leaf-like stigma.

Fig. 6. A normal stamen. Staminate flowers may have two or more stamens on a common pedicel.

Fig. 7. A flower from the edge of a staminate area invading the carpellate part of the inflorescence, showing a stigma-like structure with two imperfect pollen sacs containing microspore tetrads.

Fig. 8. A stamen-carpel complex from the edge of a staminate patch in the carpellate part, showing one anther and a twin structure which has a pollen sac on one side and a stigma-like structure on the other.

Arisaema triphyllum (L.) Torr.

Fig. 9. Carpellate flower or gynecium from the edge of a staminate area in a carpellate inflorescence showing an anther growing out of one side.

Fig. 10. Gynecium from the edge of the transition zone between the lower carpellate area and the upper staminate, showing two anthers growing from its side.

Fig. 11. Gynecium from the top of a carpellate inflorescence with an anther on its side. Otherwise the inflorescence was completely carpellate.

Fig. 12. Gynecium somewhat rudimentary with a stamen growing from the side lying next to or partly within the staminate spot of the inflorescence.

Fig. 13. Flower from transition zone between the staminate and carpellate parts of an inflorescence, showing a stigma on one side and four anthers and irregular stigmatic and distorted masses on the other.

Fig. 14. Flower from the transition zone consisting of a small rudimentary gynecium with three pollen-sacs growing out of the side next to the staminate patch of the inflorescence.

Fig. 15. A flower on the line dividing the staminate and carpellate parts of an inflorescence showing a carpellate structure with stigma on one side and a staminate structure with two pollen-sacs on the other.

Fig. 16. A number of flowers on the transition zone; one with a rudimentary stigma and ovulary from which two large anthers have developed.

Fig. 17. An area on the transition zone showing two normal carpellate flowers on one side and two staminate flowers on the other with three rudimentary gynecia; one a normal gynecium but considerably reduced, the middle one vestigial, and the third one developed as a long, horn-like neutral structure.

Myriophyllum heterophyllum Mx.

Fig. 18. A carpellate flower from the lower part of the inflorescence, showing the large stigmas, minute vestigial stamens, and very small petals.

Fig. 19. A flower from near the base of the transition zone of the inflorescence, showing petals and vestigial stamens much larger than in the carpellate flowers below and having the stigmas somewhat reduced.

Fig. 20. A flower from near the base of the transition zone with apparently normal stigmas, with intermediate petals and enlarged vestigial stamens, one stamen being considerably longer than the other three.

Fig. 21. A flower from the middle of the transition zone of the inflorescence showing petals of intermediate size, somewhat reduced stigmas, and the vestigial stamens considerably enlarged.

Fig. 22. A flower from near the top of the transition zone next to the typical staminate part, showing rather large petals, stigmas decidedly reduced, and stamens of an intermediate size between the vestiges of the carpellate flowers and the typical stamens of the staminate flowers.

Fig. 23. A staminate flower from above the transition zone of the inflorescence just before the petals open and the filaments elongate, showing normal stamens and vestigial stigmas. The larger petals have been removed.

Fig. 24. A single petal from the staminate flower of Fig. 23. showing its large size when compared with the vestigial petals of the carpellate flowers.

PLATE II.

Zizania aquatica L.

Fig. 25. A stamen and vestigial gynecium of a flower from the lower or staminate part of the panicle.

Fig. 26. The vestigial gynecium from Fig. 25 highly magnified, showing the three vestigial stigmas, the one much smaller than the other two.

Fig. 27. A bisporangiate flower from the transition zone of the panicle showing a gynecium with stigmas of nearly normal size and character and normal stamen. Five similar stamens were removed. The spikelet had an awn of half length.

Fig. 28. Gynecium and andrecium of mature carpellate flower from the upper. carpellate part of the panicle, showing the vestigial stamens and the normal stigmas.

Figs. 29-34. Spikelets from the staminate part of the inflorescence thru the transition zone to the carpellate part, showing the sex limited nature of the awn, 29 and 30 are staminate, 31 and 32 are bisporangiate, and 33 and 34 are carpellate.

Salix amygdaloides And.

Fig. 35. A typical staminate flower from the lower, staminate part of the catkin.

Fig. 36. A normal gynecium with three stigmas from the upper, carpellate part of the catkin.

Fig. 37. A normal gynecium with two stigmas.

Fig. 38. A bisporangiate flower from the broad transition zone between the staminate and carpellate parts of the catkin. The anthers on filaments are yellow, while the anther growing out of the side of the ovulary is of a brownish color characteristic of the preserved ovulary.

Fig. 39. A bisporangiate flower from the transition zone.

Fig. 40. A flower from the top of the staminate part or at the base of the transition zone, showing four normal stamens and an elongated structure with a dark color, with two microsporangia near the tip.

Fig. 41. A bisporangiate flower with one normal stigma and one stigma much reduced because of the presence of a microsporangium immediately below it.

Fig. 42. A bisporangiate flower from the transition zone of a catkin, showing a microsporangium on the side near the top of the ovulary and a stamen below.

Fig. 43. A bisporangiate flower with two short stamens arising from near the base of the ovulary and three microsporangia just below the stigmas.

Fig. 44. A structure, part carpellate and part staminate, from the transition zone.

Fig. 45. An abnormal flower with a confusion of staminate and carpellate parts.

Fig. 46. A flower showing distorted staminate and carpellate structures.

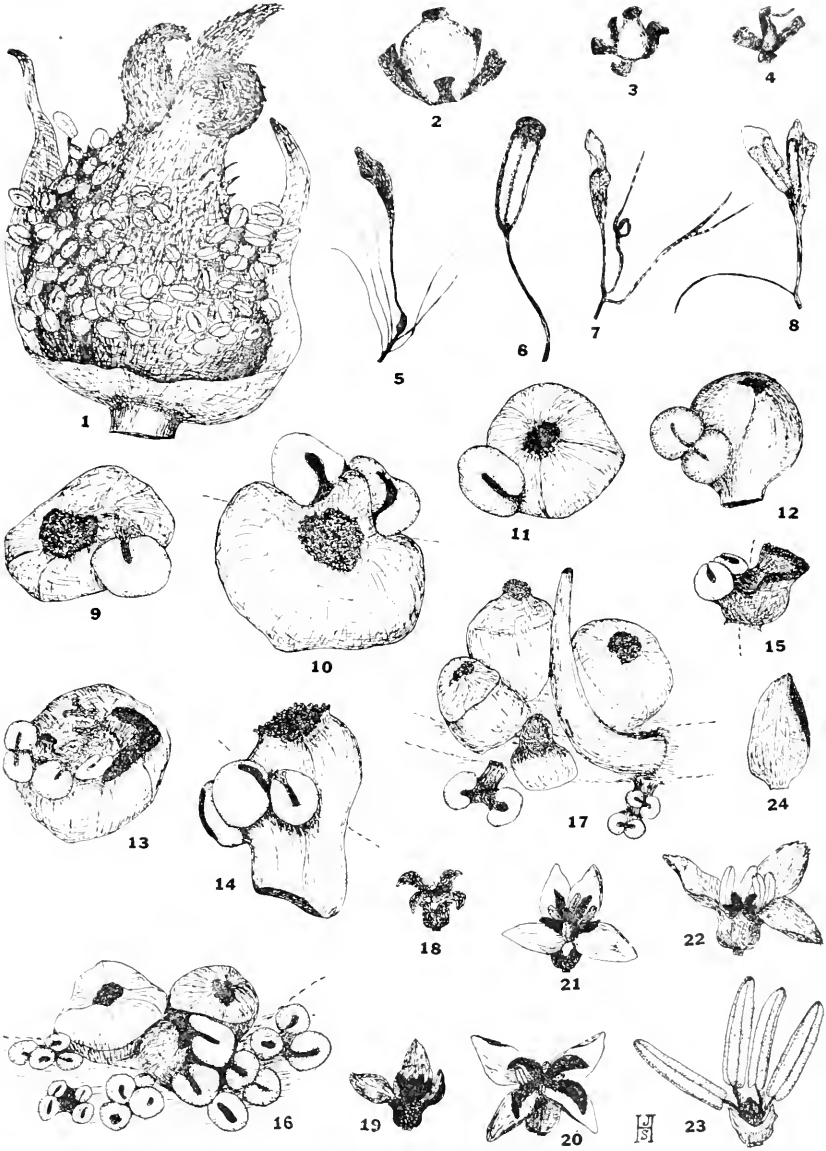
Fig. 47. A distorted structure, partly staminate and partly carpellate.

Fig. 48. A carpel-like structure with an imperfect stigma and two abnormal anthers near the top.

Fig. 49. An imperfect carpellate flower from the top of the transition zone, showing three imperfect stigmas and two small microsporangia.

Fig. 50. A carpellate flower from the top of the transition zone, showing two small stamens and an abnormal stigma from the side of the ovulary.

Fig. 51. A partly matured ovulary with seeds and with dried-up anthers on one side. From the base of the carpellate part of the catkin.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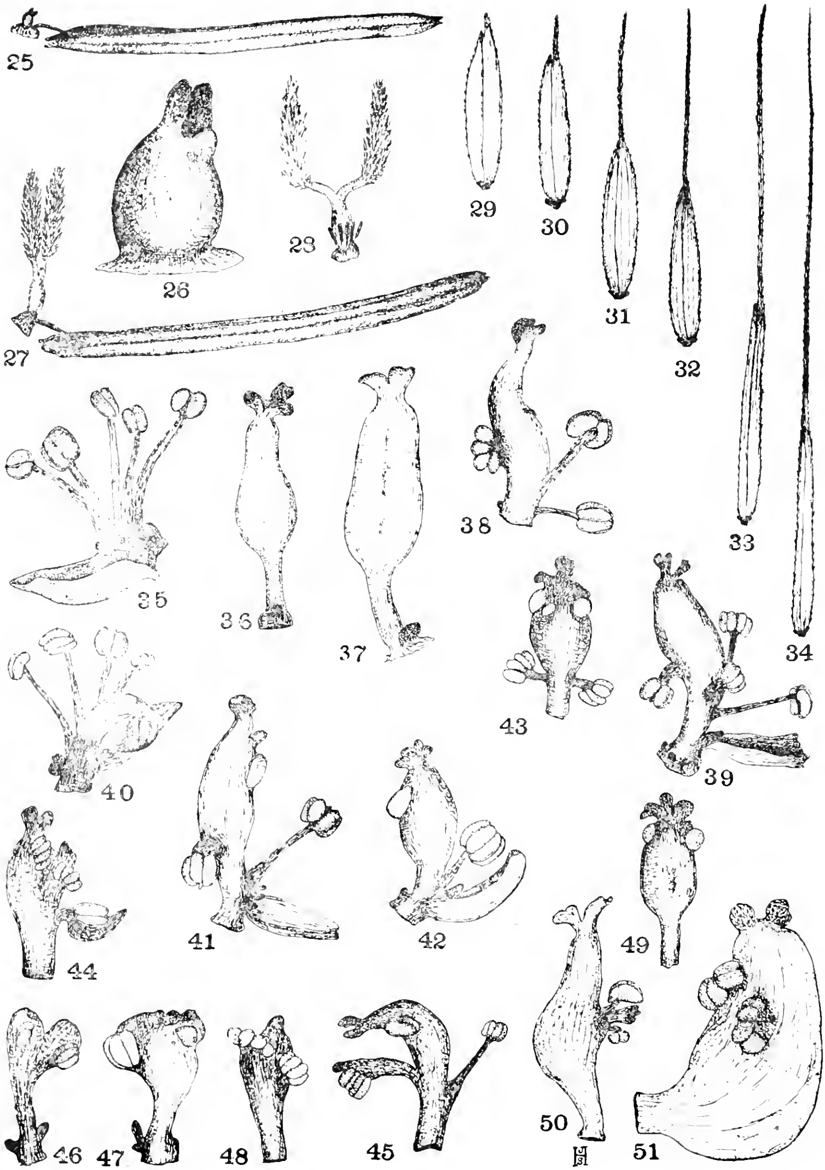
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A NEW AMBROSIA BEETLE FROM THE ADIRONDACKS; NOTES ON THE WORK OF XYLOTERINUS POLITUS SAY.*

Carl J. Drake.
New York State College of Forestry.

While collecting Ipidæ in the vicinity of Cranberry Lake, New York, in the western part of the Adirondacks during the summer of 1919, the writer found numerous specimens of an apparently nondescript Ambrosia-beetle belonging to the genus *Anisandrus* Ferr. The insect was found breeding in large beech and hard maple logs, cut from living trees during the previous winter, and in large limbs, broken off during a windstorm, upon the ground. The beech and maple logs had been skidded to a roll-way and piled with other logs—yellow birch, spruce and hemlock—from two to five deep. The roll-way was near the side of a large hill and fairly well protected from the sun by surrounding trees. The logs were all in a moribund state, fairly moist and offered a rather favorable breeding place for Ambrosia-beetles and xylophagous insects. In fact they were all infested by these insects, but the new species of Ambrosia-beetles was found only in the beech and hard maple logs.

In addition to the undescribed species of *Anisandrus*, the beech and hard maple logs on the roll-way contained larvæ, pupæ and adults of *Anisandrus obesus* Lec., *Xyloterinus politus* Say and *Pterocyclon mali* Fitch. The yellow birch logs were infested by *A. obesus, P. mali* and *Trypodendron betulæ* Swaine. The spruce and hemlock logs were inhabited by *Trypodendron bivittatum* Kirby; two bark beetles, *Polygraphus rufipennis* Kirby and *Dryocœtes piceæ* Hopkins, were also breeding in the spruce logs.

In the egg-galleries of some of the above species were found a number of rather interesting insects. A little anthocorid, *Anthocoris?* sp. is a very common predatory insect upon both bark and ambrosia beetles, especially in coniferous woods and by far the most abundant in spruce. Many specimens, representing at least four instars, were noted under the scales of the bark and in the burrows of both bark and ambrosia beetles in

* Contribution from the Department of Entomology, The New York State College of Forestry, Syracuse, New York.

spruce logs, which were badly infested by Ipidæ, during June, July and August of 1919 and 1920. No adults were found at all during the entire summer, but as large nymphs were in the majority during September, the adults probably emerge in late fall. Only very young nymphs were found in the early part of the summer. It is quite evident that the entire life history is passed in the burrows of Ipidæ and beneath the scale of the bark. At Cranberry Lake there is but a single generation a year. Numerous large nymphs were placed in breeding cages at Syracuse, but they died just before the last moult or adult state was reached. During the summer the nymphs were especially common in the burrows of *Polygraphus rufipennis*, *Dryocœtes piceæ*, *D. americana* *Orthotomicus cœlatus* and occasionally in tunnels of *Trypodendron bivittatum*. A few nymphs have also been collected in the burrows, of *Ips pini*, *Pityogenes hopkinsi*, *Dryocœtes betulæ*, *Trypodendron betulæ*, *Anisandrus obesus* and *Xyloterinus politus*. Other associated forms, including scavengers, sap-feeders, predators, etc., were as follows:

In the burrows of *Anisandrus obesus* Lec. (beech and hard maple);

Molamba lunata Lec.
Rhizophagus dimidiatus Mann.
Cerylon castaneum Say.
Colydium lineola Say.

In the burrows of *Anisandrus swainei* n. sp.

Euperea ovata Horn?

In the burrows of *Xyloterinus politus* Say and *Pterocylon mali* Fitch (in beech and Maple);

Anistoma sp.
Siagonium punctatum Lec.
Rhizaphagus bipunctatus Say.
Homalium sp. ?
Siagonum punctatum Lec.
Læmophæus biguttatus Say.
Cerylon castaneus Say.
Rhizophagus remotus Say.

Another anthocorid, *Anthocoris borealis* Dall., is occasionally taken on coniferous trees, but it is more common on deciduous trees, especially willow. A few specimens have been observed beneath the scales of the bark and in the burrows of bark

beetles, but the insect does not seem to breed or normally live beneath the bark. It prefers the branches of the trees and feeds largely upon leaf insects. Two or three adults have been taken in the burrows of Ipidæ in spruce. During September, 1919, the writer reared a specimen of *Tetraphleps* n. sp. from the burrows of *Cryptorhynchus lapathi* Linn., which was breeding in Bebb's willow, *Salix bebbiana* Sarg. This species, however, is a common insect on pine trees, feeding largely upon leaf feeding insects of the pine.

I am indebted to Mr. Chas. Dury for identifying the beetles found in the burrows of *Ipidæ* listed herein, and Mr. J. M. Swaine has very kindly compared the new species of *Anisandrus* with his types of *A. minor* and *populi*.

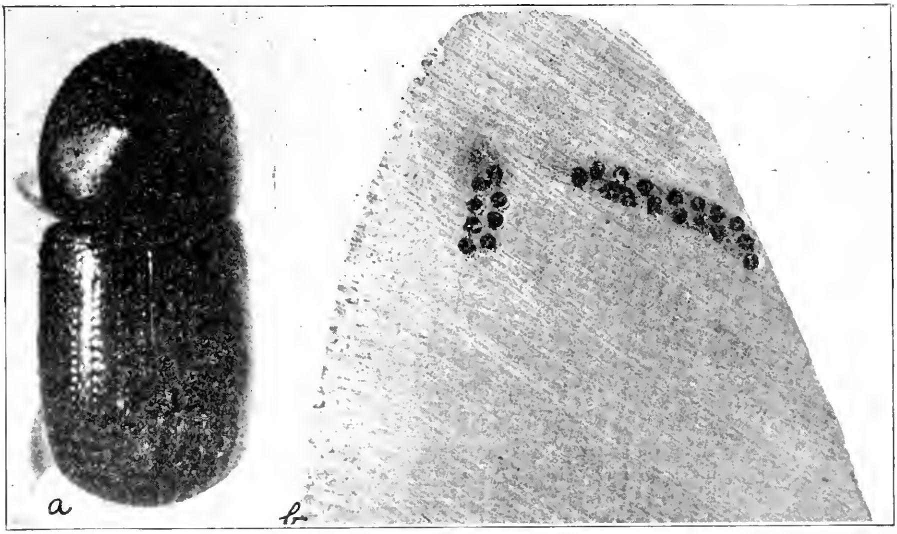

Fig. 1. *a*, *Anisandrus swainei* n. sp. (female); *b*, work of *Xyloterinus politus* Say in beech. Photo by author.

Anisandrus swainei n. sp. (Fig. 1*a*, photo of female—paratype.)

Female: Closely allied to *A. pyri* peck, but stouter and with the pronotum more acutely rounded in front and on the sides; declivity with the striæ more deeply impressed; with the sides hardly angulate at the declivity although a little stouter in form than either *A. pyri* or *A. minor*. In the key to the species of the genus Anisandrus* the female

* Swaine, J. M., Canadian Bark-beetles, Part II. Dom. Can. Dept. Agr. Bull, No. 14, 1918, p. 124.

at first glance seems to fall in with *obesus* and *populi*, rather than with *pyri* and *minor*. A careful examination will place the species in BB ("The elytra with the sides behind and the caudal margin evenly arcuate") where the insect undoubtedly belongs. Length, 3.25 mm.; width, about 2 mm.

Black or brownish black, the antennæ, tibiæ and tarsi reddish brown. Front plano-convex, punctured, sparsely hairy, the epistomal fringe not well developed and the median carina fairly distinct. Pronotum sparsely hairy, slightly broader than long, asperate in front, nearly smooth, shining, sparsely punctured and finely reticulate behind, the posterior margin truncate; disc subopaque and finely reticulate. Elytra hairy, the hairs slender, moderately long and arising from the interspaces. The declivity with the striae inpressed, the interspaces broad, the strial punctures not widely separated, the interstrial punctures sparse. The declivital ridge of the seventh interspace acute, slightly sinuate, but without teeth or tubercles. Interspaces slightly elevated, uniseriately granulate-punctate.

Male: Very distinct. It falls in Swaine's key* to the males of the genus *Anisandrus* with *obesus* and *populi* (B"The pronotum without asperites, at most with minute granules") having a somewhat shining pronotum. The pronotum and head are much smoother and less noticeably punctured than in either of the above species. Length, 1.6 to about 2 mm.

Head slightly convex in front, not very closely punctured; epistoma somewhat depressed, more densely punctured, with the usual fringe of hairs. Pronotum slightly wider than long, beset with long, slender hairs, with the granules on the cephalic portion almost entirely wanting, much smoother and more closely punctured than closely related species, subcircular in outline. Elytra with the strial punctures sparser and the interstrial punctures finer than in *populi* and *obesus*, a little wider than the pronotum, the hairs on the disc almost as long and dense as about the margin of the elytra.

Described from 6 males and 25 females, taken in hard maple and beech during July and August, 1919 and 1920, at Wanakena and Cranberry Lake, N. Y. The specimens collected during 1920 by Mr. A. E. Fivaz and the writer were in a weakened beech tree. *Dryocœtes betulæ* Hops. was also found breeding in the same beech tree by Mr. Fivaz. One burrow, containing living adults, was found in a dying yellow birch tree on Buck Island, Cranberry Lake. The work of *A. swainei* is quite similar to *A. obesus* and is found in both trunk and larger branches. *Type* (female) and allotype (male) in my collection. Paratypes in the collections of Dr. M. W. Blackman, Dr. J. M. Swaine, New York State College of Forestry and the author.

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* L. c., p. 125.

Xyloterinus politus Say. (Fig. 1*a*, work in beech.)

Very little seems to have been noted relative to the work and burrows of this species. It has long been known that the insect, like forms in the genera *Gnathotrichus*, *Pterocylon*, *Trypodendron*, etc., rears its young in separate pits or cradles, the cradles projecting in opposite direction at right angles to the main passage way and with the fiber of the wood.

The compound ambrosia tunnels of *Gnathotrichus*, *Pterocylon*, *Trypodendron*, etc., have only two rows of larval cradles, one projecting above and the other extending below the main egg-gallery. The larval cradles of *Xyloterinus politus* (Fig. 1, b) are double-compound or quadrifarious, *i. e.*, arranged in double rows or two on each side of the main passage way. Compound ambrosia beetle tunnels should then be divided into two classes: viz. (1) egg-galleries with only two rows of larval cradles, one extending above and the other below the main passage way and (2) egg-galleries with quadrifarious or tetrad-rows of larval cradles, two projecting above and two below the main passage way.

The tetrad-rows of larval cradles of *X. politus* Say were first observed by the writer while collecting Ipidæ on the roll-way described above. The insect seems to prefer beech for breeding purposes, but it is also common in maple and frequently in birch. Numerous other food plants have been recorded by Hopkins (Bull. 33, W. Va. Agr. Exp. Stat., 1893, p. 210) and Swaine (l. c., p. 83). The latter (l. c., p. 10) describes the peculiar and characteristic projection of a cylindrical rod-like mass of frass from the entrance hole while the insect is actively engaged in excavation of its tunnels. Schwarz (Proc. Ent. Soc. Wash., Vol. II, 1891, pp. 77–81) publishes notes on the breeding habits of some scolytids, including this insect, but does not describe the larval cradles. The writer examined over thirty different galleries, in most cases on both sides, and found the larval cradles of *politus* to be arranged in double rows on each side of main passage way. All specimens of work of this insect examined or at hand are from the neighborhood of Cranberry Lake in the Adirondacks. As the larval burrows have not yet been described or figured by other workers, who have published on the insect, it is impossible to state whether the double-compound larval cradles are a specific character peculiar to this insect or whether it is a race or variety living in the vicinity of Cranberry Lake, New York.

NOTES ON ELACHISTA. II. (MICROLEPIDOPTERA).

Annette F. Braun,
Cincinnati, Ohio

This paper is a continuation of "Notes on Elachista with Descriptions of New Species," which appeared in the March, 1920, number of this journal. Further rearing from mines during the past season in the vicinity of Cincinnati has resulted in the discovery of the life histories of several species previously known only in the adult stage, and in the addition of two new species.

Elachista cucullata n. sp.

Palpi white, second segment dark brown outwardly, third sometimes with fuscous shading outwardly. Antennæ black. Face and head white, except the collar, which is black. Thorax and extreme base of fore wing black; a silvery fascia almost at base, broadest on the dorsum; remainder of wing very dark brown; a silvery fascia just before middle, curved or slightly angulated on the middle of the wing, extends beyond the fold, but ends abruptly before reaching the dorsal margin; a silvery triangular spot at tornus and a little beyond it, a longer, usually oblique, costal silvery streak. Cilia dark brown. Hind wings and cilia dark grayish brown. Legs dark brown, basal segments in the male, and the tips of segments and a band around the hind tibiæ in both sexes silvery. Abdomen blackish, silvery beneath. Expanse: 8–9 mm.

Type (♂) and twenty-seven paratypes, reared from larvæ mining leaves of *Carex Jamesii*, Cincinnati, Ohio; imagoes May 13 to June 5.

The mine made during the autumn on the overwintering leaves is a narrow linear tract running down alongside the midrib, not at all or but very little enlarged until spring. Toward the end of March, the larva begins to feed actively again, and the mine becomes transparent and occupies most of the breadth of the leaf, which is inflated, due to the elevation of the midrib into a ridge on the upper side. Mines were collected March 31 and April 10; on the latter date most of the larvæ were full grown.

The larva is red; head brownish red, thorax with mid-dorsal line, abdomen with mid-dorsal and lateral lines pinkish. The coloration of the larva is retained in the pupa, with median

and lateral ridges pinkish. In general, the pupa belongs to the elongate tapering type, but the median ridge is convex from anal end to head when viewed from the side, extending out on to the head, where it divides, a projecting ridge extending on each side to the antennæ, thus forming a pointed hood which projects over the face. Lateral ridges also prominent, with prominent lateral thoracic tubercles. The pupa is attached by a median band of silk, and also enclosed in a few strands of silk.

The abrupt ending of the median fascia before it reaches the dorsum, easily distinguishes this species from all other described species. In the fore wing, veins 7 and 8 are long stalked and vein 6 arises from the extreme base of 7; other points of the venation as in the figure in Meyrick's Handbook.

Elachista enitescens n. sp.

Palpi and entire head dark leaden metallic, almost black; antennæ grayish black throughout. Thorax and base of fore wing leaden metallic, with a reddish and purplish luster which is most decided at base of dorsum, where the leaden color is sometimes replaced by metallic golden or silvery scales like those of the fascia and spots. Fore wing dark brown, faintly shining; a silvery or golden metallic fascia with reddish and purplish luster before the middle of the wing, is oblique in its costal half, broader and nearly perpendicular in its dorsal half with a slight projection along the fold; at two-thirds a silvery or golden metallic costal and an opposite dorsal spot; beyond them in the middle of the wing near the tip a silvery or golden spot. Cilia dark gray. Hind wings broad, dark brown. Legs dark gray, hind tarsi paler tipped. Abdomen dark gray, underside yellowish. Expanse: 7–7.5 mm.

Type (♂) and four paratypes (♂ and ♀), reared from larvæ mining leaves of the bulrush, *Scirpus atrovirens*, near Cincinnati; imagoes May 13 to June 8.

The larva makes a long transparent mine in a basal leaf, extending from the base of the leaf upwards. In March and the early part of April, they are mining in the old leaves, indicating that feeding began in the preceding autumn. Later the larva enters a new leaf at its base where it is not visible unless the old outer leaves are torn away. Each mine may be four or five inches in length. The larvæ feed at night only at the upper end of the mine, retreating in day time down to the base of the leaf, (sometimes beneath the surface of the water). The larva is yellow, with an ill-defined irregular darker patch

toward the posterior end of the first thoracic segment on each side of the middle. Pupation takes place toward the end of April or in May. The pupa lies on the upper surface of a leaf over the midrib and is covered by a flat cocoon, formed of two series of oblique parallel threads of silk, crossing one another at an acute angle. The pupa is more nearly allied to the stout ovate type, but the dorsal abdominal surface is flattened, without median or lateral ridges, but with a dorso-lateral series of erect short blunt spines, one spine on each abdominal segment except the first; three or four prominent lateral mesothoracic tubercles.

This species is closely allied to *E. madarella* Clemens, agreeing with it in venation and in shape of the hind wings, and differing from it only by the entirely black antennæ, the darker head, less golden base of fore wing, and darker legs. It is apparently rather rare and local, as I found the larva in but one locality, although the food plant is very common.

Elachista madarella Clemens.

Specimens of this species were reared from mines on several species of *Carex*, very commonly on *Carex pubescens* and *Carex cristata*, and on *Scirpus atrovirens*. The mine is very similar in character to that just described for *E. enitescens*, and is indistinguishable from it on *Scirpus*. The larva makes several mines, the earlier ones in the outer overwintering leaves, the later ones in the new inner basal leaves. The larva feeds in the upper end of the mine during the night, retiring down into the base of the leaf almost to the rootstock during the day. Mining larvæ were collected from April 3 to May 16.

Larva whitish or pale green, with the first thoracic segment marked with a pair of prominent dark brown or blackish L-shaped marks. Pupa covered with a flat cocoon formed of two series of parallel silken threads, as in *E. enitescens;* very similar to that of *enitescens*, but somewhat broader, with rougher thorax, and across vertex, a transverse beaded ridge, with a broad sinus in its middle.

The reared imagoes emerged from May 24 to June 28; a few captured specimens were taken as late in the season as July 10. Often the silvery gray at the base of the wing is almost entirely replaced by the pale golden color of the fascia.

Elachista leucofrons Braun.

By some confusion of data which I can not now explain, the mine and larva described as belonging to this species (Ohio Jn. Sci., XX, 170, 1920) belong to *Elachista orestella*, in which the larva is either grayish or green and marked as described. The mine of *Elachista orestella* is grayish, with epidermis wrinkled in the middle of the length of the mine, which here only is green.

The mine of *E. leucofrons* is whitish, with epidermis nowhere wrinkled; the mine lies just beneath the upper epidermis, extending usually across the leaf; the underside of the leaf remains green. The mine occurs on both *Hystrix* and *Elymus*, most commonly on the latter grass, while that of *E. orestella* occurs most commonly on *Hystrix*. The larva of *E. leucofrons* is pale grayish or greenish, with narrow mid-dorsal and broad lateral lines whitish; first segment of thorax marked posteriorly by a transverse brownish mark, curving forwards at each end.

Elachista irrorata Braun.

The larvæ of this species commonly mine leaves of *Glyceria nervata*, a tall grass occurring in moist meadows and wet places. The larva mines toward the tip of the leaf, the narrow indistinct pale yellowish green mine usually beginning low down on the leaf sheath, where the larva lies concealed during the day. The larva sometimes makes a short detached mine near the tip of the leaf; such mines are always untenanted in day time. Even when the larva is full grown, the mine is scarcely wider than the body of the larva. Mines were collected from the middle of April to the early part of May; the imagoes emerged from May 19 to June 10. Larva yellow when young, glaucous above when full grown.

The pupa is always attached near the base of the leaf on the upper side with head pointing toward the stem. The pupæ may easily be collected on the food plant at the proper season. The pupa, which shows a general resemblance to that of *E. leucofrons*, has a broader mesothorax with more tubercles, the median ridge of the abdomen more depressed, the lateral ridges projecting farther.

The occurrence of the mine of the type specimen on another species of grass (*Agrostis perennans*) was apparently accidental, as no other mines have been found on this grass. Most of the specimens reared on *Glyceria* are considerably larger than the type, expanding 8.4 to 11 mm.

NOTES ON THE POWDERY MILDEWS OF OHIO.

BRUCE FINK,
Miami University.

My interest in the powdery mildews dates from 1884, when I was a student of the first class-room teacher of mycology, the late Dr. T. J. Burrill, of the University of Illinois. My first publication on fungi dealt with this group, and my interest has never abated. My collecting in Ohio began shortly after entering the State in the summer of 1906, and two of my students, Mr. E. E. Duncan and Miss Esther Young, have spent a considerable amount of time in studying the group in my laboratory. Miss Freda M. Bachman and Mr. W. G. Stover have also aided considerably with the collecting and determinations.

Mr. A. D. Selby published "The Ohio Erysipheæ" in a Bulletin of the Ohio Agricultural Experimental Station for 1893, and Mr. W. C. O'Kane published "The Ohio Powdery Mildews" in THE OHIO NATURALIST for May, 1910. The last paper follows the nomenclature of E. S. Salmon and furnishes keys and short diagnoses. This publication will still be found useful in studying the powdery mildews of Ohio, and I only hope, in the present paper, to supplement it by additions of localities, hosts, and species not previously reported from Ohio.

The mycelia of powdery mildews usually occur on the leaves or the small stems or twigs of seed plants, and these fungi are easily collected by those who are accustomed to observe small fungi, provided that the mycelia are fairly conspicuous. In summer and autumn, these parasites may be observed on the leaves of goldenrods, asters, sunflowers, yard grass, ragweeds, verbenas, roses, willows, oaks, lilacs, and other herbs, shrubs, and trees. Less conspicuous mycelia occur on yellow sorrel, grapes, hackberry, tulip poplar, Ohio buckeye, maples, elms, chestnut, and other seed plants. In order to know whether the perithecia (Fig. 1) are in good condition and to see the inconspicuous forms at all, one should collect with a hand lens at hand. Previous consultation of a host index will add greatly to the success of the collecting trip.

The most common powdery mildew in Ohio is *Erysiphe cichoracearum* DC. This species grows on a large number of hosts and may be collected from mid-summer until late autumn. We get this fungus about Oxford, in June, for study in the laboratory at Miami University. From this time until the host plants are killed by frost, the number of hosts increases, and material for study may be had directly from the field.

Nearly as abundant and much better known is *Microsphæra alni* (Wallr.) Salm, which comes to maturity a little later and continues in condition for study from some of its

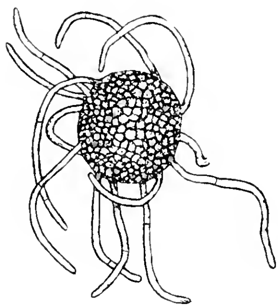

Fig. 1

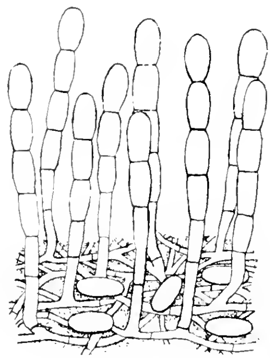

Fig. 2

Fig. 1. A perinthecium of *Sphaerotheca humuli* (DC.) Burr. on leaves of *Rosa blanda*—a form with short appendages. × 150.

Fig. 2. Mycelium, cohidiophores and conidia of Erysiphe polygoni, (DC.) on leaves of garden peas—largely diagramatical. × 150.

hosts quite as late in the season. This species is a beautiful object for microscopic study and is the form of powdery mildew most commonly used for laboratory study. However, the appendages, which are wonders of natural beauty, defy the best powers of the artist to reproduce. No drawings that I have seen do them justice, and the sketches ordinarily made by students are far from satisfactory. Some Americans who have known this species from the studies of Dr. T. J. Burrill are doubtless reluctant to follow the revision of Dr. E. S. Salmon. Yet the studies of this worker bear the stamp thoroughness, and it seems best to part company with our American pioneer at points of divergence between him and the later student of the group, with respect to this and other species of the *Erysiphaceæ*.

The powdery mildews should be collected as soon as the perithecia are mature, and if possible, while the mycellum is still fairly conspicuous. Of course the combination can not be had in species which have very evanescent mycelia. Finally, the collecting should be done before wind and rain have caused nearly all of the mature perithecia to disappear, or these fruits have become so ripe that they fall off shortly after being collected. More than once, such material collected in quantity for study in the laboratory has proved satisfactory soon after being brought in from the field, but has been found so nearly devoid of perithecia by the next year as to be practically useless for any purpose.

For successful study, the conidial stage must be taken in its prime (Fig. 2), and this is before the perithecia are mature. Young mycelia with such conidial conditions may be found at any time from the middle of June until late autumn. By seeking silvery-white, often glistening stages, devoid of perithecia, any species with a reasonably conspicuous mycelium will serve for this purpose. *Erysiphe graminis* on grasses, the species on roses, and some forms on plaintain are likely to give good conidial conditions late in the season, while quite as good material may be found on asters and other hosts.

Mr. E. E. Duncan made the collections recorded from Montgomery County. All others were made by the writer unless otherwise stated, in the additions to hosts, distribution, and species newly reported for Ohio to follow.

Sphærotheca humuli (DC.) Burr.

Butler, Hamilton, and Montgomery Counties. This seems to be the species that causes injury to our roses most commonly throughout Ohio and other portions of the United States. *Spœrotheca pannosa* (Wallr.) Lev. is said by Salmon to grow commonly on the same hosts in Europe, but to be replaced largely on the roses in America by the other species. Someone might well try to ascertain the facts regarding the cause of the disease of our roses.

Sphærotheca humuli fuliginea (Schlecht.) Salm.

Montgomery County. Known on three or four hosts from about as many localities in Ohio.

Sphærotheca phytoptophila Kell. & Swingle.

Butler and Hamilton Counties. On witches brooms of *Celtis occidentalis.*

Erysiphe cichoracearum DC.

Butler, Montgomery, and Lake Counties. Also collected in the first county by Freda M. Bachman. Very common and found on an unusually large number of host plants.

Erysiphe graminis DC.

Butler County, collected and determined by Freda M. Bachman. Probably in good condition when collected, but the herbarium specimens are practically worthless now. I have seen the conidial condition late in autumn, but have not found the perithecia in Ohio.

Erysiphe polygoni DC.

Butler and Montgomery Counties. Also collected in the first county by W. G. Stover and E. E. Duncan. This mildew is found on several hosts in Ohio. It is very common on yard grass (*Polygonum aviculare*).

Uncinula circinata Cooke & Peck.

Butler, Hamilton, and Lake Counties. Also collected in the first county by Freda M. Bachman and V. E. Lantis. The mycelium usually disappears early, but it sometimes accompanies the perithecia on the maple leaves.

Uncinula clintonii Peck.

Butler County. Also collected here by E. E. Duncan. Seen but rarely. Previously reported from two localities in Ohio, on *Tilia americana*, to which it may be confined in America.

Uncinula flexuosa Peck.

Butler County. Also collected here by E. E. Duncan. Confined to species of *Aesculus*, and little known in Ohio.

Uncinula geniculata Gerard.

Butler County, collected and determined by Freda M. Bachman and later by E. E. Duncan. On *Morus rubra*. Not previously reported from Ohio. This species is known only in North America and on the single host. The mycelium is inconspicuous.

Uncinula macrospora Peck.

Butler and Hamilton Counties. Also collected in the first county by Freda M. Bachman and W. G. Stover. Ususally found on elms in Ohio.

Uncinula necator (Schw.) Burr.

Butler and Hamilton Counties. Also collected in the first county by Freda M. Bachman and E. E. Duncan. This mildew sometimes damages grapes considerably.

Uncinula parvula Cooke & Peck.

Butler County. Also collected here by E. E. Duncan. On *Celtis occidentalis.* Not previously reported from Ohio. Known only in North America and on members of the genus *Celtis.*

Uncinula salicis (DC.) Winter.

Butler and Lake Counties. Also collected in the first county by Freda M. Bachman, W. G. Stover, and E. E. Duncan. A beautifully zonate condition, not otherwise known to me, was collected on a species of *Populus* in Lake County. Unfortunately the zonation has disappeared in the herbarium. Well known in Ohio, and confined mainly to the *Salicaceæ.*

Podosphæra oxycanthe (DC.) de Bary.

Butler County. Also collected here by W. G. Stover. Previously collected in Ohio from several localities and on three or four hosts.

Microsphæra alni (Wallr.) Salm.

Butler, Highland, Ross, and Montgomery Counties. Also collected in the first county by Freda M. Bachman, W. G. Stover, E. E. Duncan, and J. R. Wright. Probably the best known mildew in Ohio. Common on *Syringa vulgaris* and found on many other hosts. A variable and confusing species.

Microsphæra alni vaccinii (Schw.) Salm.

Butler County. Reported from a few other localities in Ohio, with species of *Vaccinium* and *Catalpa* as hosts.

Microsphæra diffusa Cooke & Peck.

Butler County. Collected here also by Freda M. Bachman and E. E. Duncan. On *Symporicarpus vulgaris.* Recorded for Ohio from several other localities and on other hosts.

Microsphæra euphorbiæ (Peck) Burk. & Curt.

Butler County. Also collected here by E. E. Duncan. Known now from but three localities in Ohio and on the single host, *Euphorbia corollata*.

Microsphæra grossulariæ (Wallr.) Lev.

Butler, Montgomery, and Lake Counties. Also collected in the first county by V. E. Lantis. Recorded for Ohio from only two other localities and only on *Sambucus canadensis*.

Microsphæra russellii Clinton.

Butler County. Collected here also by E. E. Duncan. Common enough here, but reported from only three other localities in Ohio. Easily overlooked as the mycelium is inconspicuous and usually evanescent. Found only on species of *Oxalis*, and known to me only on *Oxalis stricta*.

Phyllactinia corylea (Pers.) Karst.

Butler and Montgomery Counties. Also collected in the first county by Freda M. Bachman. On *Fraxinus americana*, *Juglans nigra*, and *Morus rubra*. Known from several localities in Ohio, but inconspicuous and usually overlooked. Formerly known under the synonym, *Phyllactinia suffulta* (Reb.) Sacc.

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THE FIGWORTS OF OHIO.*

MARY A. TAYLOR.

The following study of the species of the Scrophulariaceæ of Ohio is based upon the material in the Ohio State Herbarium and upon personal collections. Although the Figworts have for some time been grouped more or less in agreement with their phylogeny, a special attempt has been made to bring the various groups into their natural sequences, proceeding in each case from the generalized to the more specialized species, according to the principles followed by Prof. John H. Schaffner, under whom the study was made, and to whom indebtedness is gratefully acknowledged.

The nomenclature follows that of Britton & Brown's Illustrated Flora, second edition. The later important work of F. W. Pennell on the Scrophulariaceæ has been carefully considered, and all changes of nomenclature advocated by him have been indicated. It was thought best, however, for the present, in order to facilitate easy reference, to retain the older names for the list as given in the Ohio Catalogue of Vascular Plants.

The keys are based upon the characters most evident at the time of blooming and apply only to the local flora.

SCROPHULARIACEÆ. Figwort Family.

Herbs, shrubs, or trees, with opposite or alternate, and usually simple leaves, without stipules, and with perfect, zygomorphic, mostly complete flowers, in clusters or in the axils of the leaves; flowers hypogynous, tetracyclic, pentamerous or the parts reduced; corolla sympetalous, nearly regular, or commonly more or less two-lipped, sometimes spurred or saccate; calyx persistent, with four or five united sepals. Andrecium with five, four, or two fertile stamens, united with the corolla, and alternate with its lobes; if less than five, com-

* Papers from the Department of Botany, The Ohio State University, No. 124.

monly with vestiges of the missing ones, didynamous or nearly equal; anthers with four microsporangia, sometimes confluent. Gynecium with two united carpels; ovulary usually bilocular; ovules mostly numerous, rarely few, borne on axile placentæ; style simple, stigma two-lobed; fruit mostly a septicidal or loculicidal capsule; seeds usually numerous and small, the testa reticulate, pitted, striate, ribbed, or nearly smooth.

SYNOPSIS OF THE GENERA.

I. Stamens 5, (ours) all with fertile anthers; corolla more or less rotate; upper lip of corolla covering the lower in the bud; leaves alternate. VERBASCATÆ.
VERBASCEÆ.
1. *Verbascum*.

II. Stamens 4 or 2, with fertile anthers, the fifth and sometimes the two lateral ones sterile or reduced to mere vestiges, or sometimes entirely absent; corolla usually tubular, sometimes more or less rotate.

A. Capsule opening by valves, either loculicidal or septicidal; corolla not spurred, sometimes gibbous or saccate, corolla usually without a palate in the throat, not with 2 sack-like lips.

1. Upper lip or lobe of the corolla usually covering the lower in the bud; capsule usually septicidal. SCROPHULARIATÆ.

a. Fifth or sterile filament present, sometimes longer than the fertile, sometimes gland-like or scale-like; herbs; inflorescence usually compound, cymose, or if single, the peduncle mostly 2-bracteate. CHELONEÆ.
2. *Penstemon*. 3. *Chelone*. 4. *Scrophularia*. 5. *Collinsia*.

b. Fifth stamen absent; trees with opposite leaves; inflorescence large panicle. PAULOWNIEÆ.
6. *Paulownia*.

c. Fifth stamen vestigial, small; herbs; flowers solitary in axils of bracts or leaves.

(a). Stamens 4, all anther-bearing and similar. MIMULEÆ.
7. *Mimulus*. 8. *Conobea*.

(b). Anther-bearing stamens 2, sometimes 2 additional filaments present. GRATIOLEÆ.
9. *Gratiola*. 10. *Ilysanthes*.

2. Under lip or the lateral lobes of the corolla enfolding the upper in the bud; capsule commonly loculicidal. RHINANTHATÆ.

(1). Fertile stamens 4 or 2, not didynamous, or if so, their anthers not enclosed by the upper lip.

a. Stamens 4, all anther-bearing; corolla campanulate, salverform, or funnelform, scarcely 2-lipped.

(a). Ours with the leaves alternate; cavities of the anthers finally confluent at the top; not parasitic. DIGITALEÆ.
11. *Digitalis*.

(b). Ours with the leaves, at least the lower, opposite; cavities of the anthers continuously distinct; plants commonly more or less parasitic. BUCHNEREÆ.
12. *Afzelia*. 13. *Dasystoma*. 14. *Agalinis*. 15. *Otophylla*. 16. *Buchnera*.

b. Fertile stamens only 2, rarely 4; corolla rotate, salverform, tubular, or none. VERONICEÆ.
17. *Leptandra.* 18. *Veronica.* 19. *Synthyris.*

(2). Fertile stamens 4, ascending, their anthers enclosed by the upper lip of the corolla.

a. Cavities of the ovulary with several to numerour ovules. EUPHRASIEÆ.
20. *Pedicularis.* 21. *Castilleja.*

b. Cavities of the ovulary each with 1 or 2 ovules.
22. *Melampyrum.*

B. Capsule usually opening by chinks or holes; corolla spurred or prominently saccate, or with a palate in the throat, or decidedly 2-lipped, the lips broad and sack-shaped; upper lip of the corolla covering the lower in the bud. ANTIRRHINATÆ.

1. Corolla tubular, prominently spurred or saccate, its throat usually closed by the palate; fertile stamens 4, a fifth, minute, vestigial stamen sometimes present.
ANTIRRHINEÆ.
23. *Antirrhinum.* 24. *Linaria.* 25. *Chaenorrhinum.*
26. *Kickxia.* 27. *Cymbalaria.*

2. Corolla 2-lipped, sack-shaped, or the lower one large and slipper-shaped; stamens only 2. CALCEOLARIEÆ.
28. *Calceolaria.*

KEY TO THE GENERA.

1. Anther-bearing stamens 5, the fifth smaller; corolla rotate; leaves alternate. *Verbascum.*
1. Anther-bearing stamens 4 or 2........2
2. Anther-bearing stamens 4........3
2. Anther-bearing stamens 2........23
3. Corolla definitely spurred on the lower side........4
3. Corolla not spurred, although it may be gibbous or saccate........7
4. Flowers in terminal racemes; leaves narrow........*Linaria*
4. Flowers solitary in the axils........5
5. Leaves linear-spatulate to linear; flowers blue or bluish; throat of the corolla not closed by the palate........*Chaenorrhinum*
5. Leaves broad, pinnately or palmately veined; the throat of the corolla nearly or quite closed by the palate; flowers yellowish, variegated, or lilac........6
6. Leaves pinnately-veined, entire........*Kickxia*
6. Leaves palmately-veined, coarsely toothed; creeping vine........*Cymbalaria*
7. Trees with large, heart-shaped, opposite, entire leaves; violet, panicled flowers........*Paulownia*
7. Herbs........8
8. Stamens not enclosed in the upper lip of the corolla, or apparently enclosed in the young condition, either included in the throat, exserted, or enfolded by the lower petal; upper lip of the corolla not galeate, or if slightly so, the vestigial stamen large........9
8. Stamens ascending under the upper lip of the corolla; the corolla decidedly 2-lipped, the upper lip galeate; the fifth stamen either minute or wanting..21
9. Corolla decidedly saccate or gibbous on the lower side, with a prominent palate closing the throat; the fifth stamen very minute; leaves mostly alternate, entire; upper lip of the corolla covering the lower in the bud........*Antirrhinum*
9. Corolla tubular or only slightly gibbous, without a palate; frequently with the fifth, sterile stamen prominent........10
10. Fifth or sterile stamen prominent, either a filament, scale, or large gland; upper lip of the corolla covering the lower in the bud........11
10. Fifth stamen minute or wanting........14

11. Corolla 2-cleft, the middle lobe of the lower lip conduplicate, enclosing the stamens and filiform style; odd sterile stamen gland-like....... *Collinsia*
11. Lower lip of the corolla not enclosing the stamens and style; the fifth stamen not gland-like, either a long filament or a scale.................. 12
12. Fifth or sterile stamen reduced to a scale on the upper lip of the inflated corolla; stem 4-angled.................................... *Scrophularia*
12. Fifth or sterile stamen a filament, prominently bearded or glabrous; stem cylindrical or only slightly 4-sided.................................. 13
13. Corolla somewhat 2-lipped, the upper lip 2-lobed, not arched or keeled; sterile stamen nearly as long, or sometimes longer than the fertile ones, frequently prominently bearded; inflorescence thyrses, panicles, or racemes, sometimes spike-like at the tip..................... *Penstemon*
13. Corolla decidedly 2-lipped, the upper lip arched, keeled in the middle and notched at the apex; sterile stamen shorter than the fertile ones; flowers in terminal and axillary dense spikes.......................... *Chelone*
14. Calyx prismatic; leaves opposite; stem square; flowers axillary.... *Mimulus*
14. Calyx not prismatic.. 15
15. Leaves alternate; flowers in one-sided racemes.................. *Digitalis*
15. Leaves, at least the lowest, opposite.................................. 16
16. Sepals free nearly to the base, linear; upper lip of the corolla covering the lower in the bud, emarginate or 2-lobed; stamens included; annual, diffusely branched, pubescent herbs, with pinnately-parted leaves.. *Conobea*
16. Calyx with a considerable tube, campanulate or turbinate................ 17
17. Corolla salver-form, purple; flowers in a long, peduncled spike..... *Buchnera*
17. Corolla campanulate or funnel-form; flowers not in a long, peduncled spike. 18
18. Filaments glabrous or nearly so; leaves all, or some of them, auricled at the base; stamens didynamous, the anthers of the shorter stamens smaller.. *Otophylla*
18. Filaments wholly, or in part, pubescent or villous; leaves not auricled.... 19
19. Stamens nearly equal; calyx lobes as long as the tube; corolla yellow; lower leaves long-petioled and pinnately-parted.................. *Afzelia*
19. Stamens unequal, strongly didynamous; calyx teeth shorter than the tube.. 20
20. Anthers awned at the base; corolla yellow; leaves parted, lobed, or toothed, or if the upper are entire, then lanceolate or ovate-lanceolate.... *Dasystoma*
20. Anthers awnless; corolla purple, pink, or rarely white or yellowish; leaves narrowly linear or linear-lanceolate............................ *Agalinis*
21. Leaves opposite, entire; ovules 2–4........................ *Melampyrum*
21. Leaves alternate, or if opposite or whorled, then compound or lobed; ovules numerous.. 22
22. Anther-sacs dissimilar, the inner one pendulous by its apex; floral bracts brightly colored; leaves parallel-veined........................ *Castilleja*
22. Anther-sacs similar and parallel; bracts of the inflorescence not brightly colored; leaves pinnately-veined............................ *Pedicularis*
23. Corolla strongly 2-lipped, large and showy, the lower lip sack-shaped and broad; cultivated; sepals 5 or frequently the two lower more or less united... *Calceolaria*
23. Corolla nearly regular, or if 2-lipped, the lips not sack-like................ 24
24. Corolla 2–3 lobed or none; leaves alternate; flowers in dense, terminal, elongated spikes or racemes..................................... *Synthyris*
24. Corolla 4–5 lobed; at least the lower leaves opposite or whorled.......... 25
25. Calyx 4-lobed, rarely 5-lobed, the under lip or lobes of the corolla enfolding the upper in the bud; flowers solitary in the axils or in racemes or spike-like.. 26
25. Calyx 5-lobed; upper lip of the corolla covering the lower in the bud........ 27
26. Corolla tubular or salver-form, much longer than the calyx; stamens much exserted, nearly parallel; leaves opposite or verticillate, or both; tall herbs, 2–7 ft. high.. *Leptandra*
26. Corolla wheel-shaped, tube short; leaves usually opposite below and alternate above; stamens divergent; low or spreading herbs, 3–30 in. *Veronica*
27. Peduncles 2-bracteate at the summit; flowers yellow or whitish..... *Gratiola*
27. Peduncles not bracteate at the summit; flowers purplish........... *Ilysanthes*

1. **Verbâscum** (Tourn.) L. Mullen.

Mostly biennial, erect herbs, with alternate leaves, and prominent winter rosettes. Flowers pentamerous, in terminal spikes, racemes, or panicles. Corolla rotate; the fifth stamen anther-bearing; some or all of the stamen filaments pilose; ovules and seeds numerous.

1. Plants glabrous or sparingly glandular-pubescent; flowers racemose. *V. blattaria.*
1. Plants densely woolly; flowers in dense spikes or spike-like racemes. *V. thapsus.*

1. **Verbascum blattâria** L. Moth Mullen.

Stem slender, erect, usually simple, glabrous or sparingly glandular-pubescent, 2–6 ft. high. Leaves oblong to ovate, or lanceolate, dentate or pinnatifid, the upper ones more or less clasping, ½–2½ in. long, the basal ones sessile or short-petioled, up to 12 in. or more in length, forming rosettes, and in late autumn strongly geotropic, pressed close to earth, and with much anthocyan present. Corolla yellow or white, about 1 in. broad; filaments pilose, magenta. General and abundant in lawns, fields, and waste places. June–Nov. Naturalized from Europe. Flowers and leaves used as medicine.

2. **Verbascum thâpsus** L. Great Mullen.

A stout, erect, usually simple biennial, 2–7 ft. high, densely woolly all over, and with large winter rosettes. Stem leaves thick, 4–12 in. long, prominently decurrent, the rosette-leaves up to 18 in. long. Flowers yellow, ½–1 in. broad, sessile or nearly so, in dense spikes. Fields, waste places, and pastures, especially on hillsides. June–September. General and abundant. Naturalized from Europe.

2. **Penstêmon** Mitch. Beard-tongue.

Erect, perennial herbs with opposite leaves and large, usually showy flowers in terminal thyrses, panicles, or racemes. Corolla tubular, inflated, 2-lipped, the upper lip not arched. Stamens 5, included, 4 of them didynamous, anther-bearing, the fifth sterile, frequently bearded, nearly as long as or longer than the fertile ones. Seeds numerous.

1. Plants more or less glandular or pubescent; leaves dentate or serrate........2.
1. Plants glabrous throughout and glaucous; leaves entire......*P. grandiflorus.*
2. Corolla-tube not prominently enlarged; ½–1¼ in. long; leaves serrate or denticulate; thyrsus elongated and open, usually branched, panicle-like...3.
2. Corolla-tube much enlarged above, 2 in. long; thyrsus short; leaves dentate. *P. cobaea.*
3. Only inflorescence or calyx pubescent, or if pubescent to the base, the upper leaves ovate-lanceolate and usually tapering from near the broad base; throat of corolla slightly bearded...4.
3. Stems pubescent or puberulent nearly to the base; upper leaves usually narrowly-lanceolate; corolla bearded in the throat..............*P. hirsutus.*
4. Corolla-tube not gibbous above the point of enlargement; corolla purplish; stems usually puberulent; anther-sacs usually glabrous.........*P. penstemon*
4. Corolla-tube gibbous above the point of enlargement; corolla white or purplish; stems usually glabrous; anther-sacs barbate usually...*P. digitalis.*

1. **Penstemon penstèmon** (L.) Britt. Tall Purplish Beard-tongue.

Usually puberulent, the inflorescence glandular-pubescent, 2–3 ft. high. Leaves 3–6 in. long, the lower ones narrowed into margined petioles, the upper ones sessile or slightly clasping, acute, oblong or lanceolate, denticulate. Inflorescence usually a many-flowered, open thyrsus; corolla purple or purplish, $\frac{5}{8}$–$\frac{7}{8}$ in. long. Anther-sacs usually glabrous. In fields and thickets. May–July. General.

2. **Penstemon digitàlis** (Sweet) Nutt. Foxglove Beard-tongue.

Usually glabrous, 2–5 ft. high, the inflorescence glandular-pubescent. Leaves 2–8$\frac{1}{2}$ in. long, the lower and basal ones oblong or oval, narrowed into margined petioles, the upper ones sessile or clasping, lanceolate or ovate-lanceolate. Inflorescence a many-flowered, open thyrsus; corolla white or purplish, 1–1$\frac{1}{4}$ in. long, the limb somewhat 2-lipped, the throat open. Anther-sacs usually barbate. In fields and thickets. May–July. General.

This is not very definitely separated from the preceding species, and possibly does not deserve specific rank. Specimens collected from the same limited area show smooth stems and barbate anther-sacs, puberulent stems and glabrous anther-sacs, and puberulent stems and barbate anther-sacs.

3. **Penstemon hirsùtus** (L.) Willd. Hairy Beard-tongue.

Stems slender, erect, sometimes tufted, downy-hirsute and more or less glandular to the base, frequently purplish, 1–3 ft. high. Leaves puberulent or glabrous, denticulate or the uppermost entire, the basal ones oblong or ovate, narrowed into petioles, the upper ones oblong to lanceolate, sessile or slightly clasping. Inflorescence thyrsoid, rather loose, glandular-pubescent; corolla purplish or violet, about 1 in. long, the tube gradually dilated above, the throat nearly closed by the villous palate. In dry woods and thickets, also on exposed limestone cliffs. May–July. General.

4. **Penstemon cobaèa** Nutt. Cobaea Beard-tongue.

Stem stout, densely and finely pubescent below, glandular-pubescent above, 1–2 ft. high. Leaves firm, oblong to ovate, 3–5 in. long, mostly sharply serrate, the lower ones mostly glabrous with margined petioles, the upper ones sessile or cordate clasping, usually pubescent. Thyrsus short, several-many-flowered; flowers about 2 in. long; corolla dull reddish-purple or paler, puberulent without, glabrous within, its tube narrow up to the top of the calyx, then abruptly dilated and campanulate, the limb slightly 2-lipped, the lobes short, rounded, and spreading. Capsule ovoid, acute, pubescent. On prairies. May–July. Lake County.

5. **Penstemon grandiflòrus** Nutt. Large-flowered Beard-tongue.

Glabrous and somewhat glaucous with stout stem, 2–4 ft. high. Leaves thickish, entire, the basal ones obovate, narrowed into broad

petioles, the lower stem-leaves sessile, oval or oblong, 1–2½ in. long, the upper stem-leaves nearly orbicular, cordate-clasping, shorter. Thyrsus open, the bracts leaf-like, orbicular, cordate; flowers 2 in. long; corolla lilac or lavender-blue, the tube rather abruptly dilated above the calyx, the limb somewhat 2-lipped. Capsule acute, considerably longer than the calyx. On prairies, especially on flood-plains. Hamilton County.

3. **Chelòne** (Tourn.) L. Turtlehead.

Glabrous perennials, with opposite, serrate leaves, and large white, red, or purple flowers in dense, terminal and axillary spikes or spike-like racemes. Calyx of five distinct sepals, subtended by sepal-like bracts. Corolla inflated-tubular, two-lipped, the upper lip arched, the lower densely pubescent, the two lateral lobes larger than the middle one. Andrecium with five stamens, included, the filaments bearded, four of the stamens didynamous, with densely woolly, heart-shaped anthers, the fifth sterile and shorter than the others. Seeds numerous, flattened, winged.

1. **Chelone glàbra** L. Smooth Turtlehead.

A slender, erect, smooth-stemmed perennial, 1–3 ft. high. Leaves opposite, linear-lanceolate to ovate-lanceolate, 3–6 in. long, ½–1¼ in. wide, narrowed at the base into a short petiole; leaf margins serrate with sharp, appressed teeth. Flowers white, sometimes delicately tinged at the tips with pink, about 1 in. long, and very striking in appearance. In swamps, wet places, and along streams. July–September. Leaves used as medicine.

4. **Scrophulària** (Tourn.) L. Figwort.

Perennial, strong-scented herbs, ours with four-angled stems, usually with opposite leaves, and with small, green or yellow flowers in loose, terminal panicles or cymes. Corolla with a short, somewhat globular tube, the two upper and two lateral lobes erect, the lower one spreading or reflexed. Andrecium with five stamens, four anther-bearing and declined, the fifth one reduced to a sterile scale on the upper lip of the corolla. Seeds numerous, wingless, wrinkled.

1\. Sterile stamen deep purple; corolla dull outside; panicle broad; petioles slender, scarcely margined. . . . . *S. marylandica.*

1\. Sterile stamen greenish-yellow; corolla shining outside; inflorescence narrowly elongated; petioles stout, evidently wing-margined . . . . *S. leporella.*

1. **Scrophularia marylándica** L. Maryland Figwort.

Perennial, glabrous below, somewhat glandular-pubescent above, with slender, 4-sided, grooved stem, 3–10 ft. high, and light green leaves, membranous, usually puberulent beneath, ovate or ovate-lanceolate, sharply serrate, long-petioled, 3–12 in .long, the petioles slender, scarcely margined. Flowers small, on pedicels ⅓–1 in. long, clustered on a long, nearly leafless, broad panicle. Corolla ⅜ in. long, green, dull without, and brownish purple and shining within. Sterile stamen deep purple. Capsule subglobose with a slender tip. In woods and thickets. July–September. General.

2. **Scrophularia leporélla** Bickn. Hare Figwort.

Simple or somewhat branched perennial, 3–8 ft. high, with sharply 4-angled stem with flat sides, the lower part of the plant puberulent, the upper part viscid-glandular. Leaves ovate to lanceolate, narrowed at the base or sometimes subcordate, glabrous on both sides when mature, usually incised-dentate, 2–10 in. long, short-petioled, the petioles evidently wing-margined. Flowers ⅜–½ in. long, in a narrow, elongated panicle. Corolla green to purple, shining without, dull within. Sterile stamen greenish-yellow. Capsule ovoid-conic. In woods and along roadsides. May–July. Cuyahoga, Ashtabula, and Belmont Counties.

5. **Collínsia** Nutt. Collinsia.

Winter-annual or biennial herbs, with opposite or verticillate leaves. Flowers blue, white, pink, or variegated, verticillate or solitary in the axils. Corolla two-lipped, the upper lip two-cleft, the lobes erect or recurved, with a slight palate; the lower one three-cleft, the middle one conduplicate, enclosing the four stamens and filiform style. Vestigial stamen gland-like, short, with a green tip. Seeds few, large.

1. **Collinsia vérna** Nutt. Blue-eyed-Mary.

A slender, branching herb, with weak stem, 6 in.–2 ft. high, glabrous or puberulent. Leaves opposite or verticillate, the lower broadly ovate or orbicular, obtuse, rounded, narrowed, or subcordate at the base, crenate or entire, slender-petioled, the upper ones sessile or clasping, 1–2 in. long, ovate or oblong. Corolla slightly pubescent within, the upper lip white, with a slight, purple-spotted palate, the lower one dark blue or sometimes nearly white, with scattered hairs on the outside. Upper pair of stamens glabrous or nearly so, the lower pair pubescent below. Moist woods and hillsides. April–June. General.

6. **Paulòwnia** S. & Z. Paulownia.

A large tree, with broad, opposite, entire or three-lobed, petioled leaves, superposed, axillary buds, prominent lenticels, and more or less diaphragmed pith. Flowers large, violet, in

terminal panicles. Stamens four, didynamous, the lateral ones shorter, the fifth one absent. Capsule ovoid, acute. Seeds numerous, winged.

1. **Paulownia tomentôsa** (Thunb.) Baill. Paulownia.

A tree, with thin, flaky bark, up to 70 ft. high, with a trunk diameter of 4 ft., and with broad, heart-shaped leaves, persistently pubescent beneath, 6–15 in. long, 4–8 in. wide, and long, often hollow petioles. Sepals 5, very thick and tomentose; corolla glandular-pubescent on the outside; ovulary densely glandular-pubescent. May July. Cultivated in Southern Ohio, and escaped in Lawrence County.

7. **Mímulus** L. Monkey-flower.

Erect or creeping, perennial herbs, with opposite, usually dentate leaves, and showy, pink, violet, or yellow, peduncled flowers, solitary in the axils, or raceme-like. Calyx prismatic, 5-toothed or lobed. Corolla tubular, 2-lipped. Stamens 4, didynamous, all anther-bearing. Capsule many-seeded, enclosed by the calyx.

1. Leaves sessile, clasping, prevailingly lanceolate; peduncles considerably longer than the calyx.......... *M. ringens.*
1. Leaves petioled, prevailingly ovate; peduncles mostly shorter than the calyx.......... *M. alatus.*

1. **Mimulus ríngens** L. Square-stemmed Monkey-flower.

Perennial, glabrous plant, with erect, 4-sided, or somewhat 4-winged stem, often considerably branched, 1–3 ft. high. Leaves oblong or lanceolate, acuminate at the apex, clasping by a heart-shaped base, or the lower ones merely sessile, 2–4 in. long, ½–1 in. wide. Flowers solitary and axillary; peduncles considerably longer than the calyx; corolla 1–1½ in. long, violet, or rarely white, with 2 yellow spots near the narrow throat, the upper lip erect, the lower spreading; calyx lobes lanceolate. In swamps, along streams, and in wet places. June September. General.

2. **Mimulus alàtus** Soland. Sharp-winged Monkey-flower.

Perennial, glabrous, similar to the preceding species, but with sharply 4-angled stem, the angles more or less winged. Leaves ovate, ovate-lanceolate, or oblong, narrowed at the base, petioled, 2–5 in. long, ¾–1½ in. wide; petioles ¼–1 in. long. Calyx-lobes setaceous-tipped. Peduncles shorter than the calyx. In swamps and wet places. June–September. Rather general.

8. **Conòbea** Aubl. Conobea.

Low, branching herbs, with opposite, pinnately-parted or serrate leaves, and small, blue or white flowers, solitary or two together in the axils. Calyx of 5, equal, linear sepals, free nearly to the base. Corolla 2-lipped. Stamens 4, fertile, didynamous, included. Anther-sacs parallel. Seeds numerous.

1. **Conobea multífida** (Mx.) Benth. Conobea.

A viscid-pubescent, diffusely spreading, much branched annual, 4–8 in. high. Leaves opposite, ½–1 in. long, pinnately-parted, the segments linear or linear-oblong. Flowers small, blue; corolla slightly longer than the calyx. Along streams and rivers. June–September. Hamilton, Greene, Madison and Ottawa Counties.

9. **Gratìola** L. Hedge-hyssop.

Low herbs inhabiting wet or damp places, with opposite, sessile, entire or dentate leaves. Flowers white or yellowish, peduncled, solitary and axillary, usually with two bractlets at the base of the calyx. Corolla more or less two-lipped. The two upper stamens fertile, the lower pair vestigial, minute, or sometimes represented by two slender, capitate filaments. Seeds numerous, striate.

1. Plant glabrous or nearly so; peduncles much shorter than the subtending leaf-bracts; corolla within throat pubescent with knobless hairs. *G. sphaerocarpa.*
1. Plant glandular-puberulent; peduncles as long as or longer than the subtending leaf-bracts; corolla within throat pubescent with knobbed hairs. *G. virginiana.*

1. **Gratiola sphaerocàrpa** Ell. Round-fruited Hedge-hyssop.

Glabrous, ascending or erect, annual, simple or branched, 6–12 in. high. Leaves oblong or obovate-oblong, sessile, toothed, 3–5 nerved, narrowed at the base, 1–2 in. long, ¼–¾ in. wide. Peduncles stout, much shorter than the subtending leaf-bracts. Flowers small, the corolla tube yellow, the limb paler; corolla within throat pubescent with knobless hairs. Capsule globose. In wet places. June–September. Erie County. (**Gratiola virginiana** L., according to Pennell.)

2. **Gratiola virginiàna** L. Clammy Hedge-hyssop.

Annual, stem glandular-puberulent above, widely branched, 3–12 in. high. Leaves oblong or oblong-lanceolate, sessile, narrowed at both ends, entire or sparingly toothed, 1–2 in. long, ⅛–½ in. wide. Peduncles slender, glandular, nearly as long as or longer than the subtending leaf-bracts. Corolla-tube yellowish; limb almost white; corolla within throat pubescent with knobbed hairs; sterile filaments minute or none. Capsule broadly ovoid, as long as the calyx. In wet places. May–October. General. (**Gratiola neglecta** Torr., according to Pennell.)

10. **Ilysánthes** Raf. False Pimpernel.

Small, smooth, annual or biennial herbs, with opposite, sessile, usually dentate leaves. Flowers small, purplish, peduncled, without bracts, solitary in the axils. Corolla two-lipped. The two upper stamens fertile, and included, the two lower ones sterile, two-lobed, the one lobe capitate and glandular, the other smooth and shorter. Seeds numerous, wrinkled.

1. Peduncles longer than the subtending leaf-bracts; calyx-segments shorter then the capsule .... *I. dubia.*
1. Peduncles shorter than the subtending leaf-bracts; calyx-segments as long as the capsule or longer .... *I. attenuata.*

1. **Ilysanthes dûbia** (L.) Barnh. Long-stalked False Pimpernel.

Stem square, at first simple and usually erect, later much branched and diffusely spreading, 3–10 in. long. Leaves ovate, obovate, or oblong, usually sessile, clasping, entire or sparingly toothed, ½–1 in. long. Corolla pale lilac, ¼–½ in. long, the peduncles usually considerably longer than the subtending leaf-bracts; calyx-segments usually shorter than the capsule. In wet places. July–September. Meigs, Fairfield, Licking, Franklin, Huron, Auglaize, Defiance and Scioto Counties.

2. **Ilysanthes attenuâta** (Muhl.) Small. Short-stalked False Pimpernel.

Stem square, erect or ascending, 3–16 in. long, the branches spreading. Leaves ovate, obovate, or oblong, ½–1⅝ in. long, sparingly toothed. Corolla pale lilac to nearly white, ⅛–½ in. long; peduncles mostly shorter than the subtending leaf-bracts; calyx-segments as long as the capsule or longer. In wet places. May–October. Cuyahoga, Stark, Summit, Madison, Scioto, and Highland Counties.

The two species are evidently closely related as intermediates show peduncles longer than the subtending leaf-bracts, but with calyx-segments as long as the capsule.

11. **Digitàlis** (Tourn.) L. Foxglove.

Tall, erect herbs, with alternate, entire or dentate leaves, and showy, yellow, purple, or white flowers in long, terminal, usually one-sided racemes. Calyx 5-parted. Corolla declined, slightly two-lipped, the tube contracted above the ovulary, then abruptly inflated. Stamens four, didynamous, included. Seeds numerous, rugose.

1. Corolla purple to white, 1½–2 in. long; stem pubescent; leaves slender-petioled .... *D. purpurea.*
1. Corolla yellow, about ¾ in. long; stem smooth; leaves sessile .... *D. lutea.*

1. **Digitalis purpùrea** L. Purple Foxglove.

Stout, erect, pubescent herb, usually biennial, 2–5 ft. high. Lower leaves ovate or ovate-lanceolate, 6–10 in. long, acute at the apex, narrowed at the base into petioles, dentate; upper leaves smaller, sessile. Racemes 1 ft. or more in length, dense, one-sided; flowers purple to white, 1½–2 in. long, drooping, the corolla spotted within; upper calyx-lobe narrower than the others. Escaped from cultivation June–August. Cuyahoga and Lake Counties. From Europe.

Leaves of the second year's growth used officially as medicine.

2. **Digitalis lùtea** L. Yellow Foxglove.

Glabrous perennial, 2–3 ft. high. Leaves oblong or lanceolate, denticulate, 4–4½ in. long, ¾ in. wide, ciliate only on the margin, sessile, narrowed at the base. Raceme many-flowered; corolla yellow to white, glabrous outside; calyx-segments lanceolate, acute. June–August. A waif in Cuyahoga County. From Europe.

12. **Afzèlia** Gmel. Mullen Foxglove. (**Dasistoma** Raf., according to Pennell).

Erect herbs with opposite leaves, and yellow flowers solitary in the axils of leaf-like bracts. Corolla rotate-campanulate, the lobes nearly equal, and longer than the tube. Stamens 4, slightly unequal, not exserted; anthers glabrous; filaments short, villous; anther-sacs parallel and distinct. Seeds numerous, reticulated.

1. **Afzelia macrophýlla** (Nutt.) Ktz. Mullen Foxglove.

Puberulent or glabrate, simple or sparingly branched, 4–6 ft. high, perennial by buds in the crown. Lower leaves long-petioled, pinnately-divided, 6–15 in. long, the segments dentate or pinnatifid; the upper leaves short-petioled or sessile, entire, 1–3 in. long. Flowers ½–⅝ in. long, sessile and solitary in the axils of the upper leaves; calyx-lobes lanceolate or ovate; corolla yellow, 2–3 times as long as the calyx, the corolla-tube, except the lower part, very woolly inside. Capsule globose, pointed. In thickets, and along streams. August–October. General in western Ohio, as far east as Huron, Noble, and Vinton Counties. (**Dasistoma macrophylla** (Nutt.) Raf., according to Pennell.)

13. **Dasistoma** Raf. False Foxglove. (**Aureolaria** Raf., according to Pennell).

Large, erect herbs, more or less parasitic on the roots of other plants, with opposite, or whorled, or some alternate leaves, and large, showy, yellow flowers in terminal, usually leafy-bracted racemes. Calyx campanulate or turbinate, 5-lobed, the lobes sometimes foliaceous. Corolla funnel-form or campanulate-funnelform, with five rather unequal, spreading lobes, the tube villous or pubescent within. Stamens 4, didynamous, included, villous or pubescent, the anther-sacs parallel and awned at the base. Capsule oblong, acute.

1. Leaves all toothed or pinnatifid .... 2.
1. Leaves, at least the upper ones, entire .... 3.
2. Plants, especially the stems, glaucous or glabrous; calyx and corolla glabrous outside; perennial .... *D. virginica*.
2. Plants glandular-pubescent or hirsute; calyx and corolla pubescent outside; annual .... *D. pedicularia*.
3. Plants pubescent; calyx pubescent outside .... *D. flava*.
3. Plants glabrous; calyx glabrous outside; leaves all entire or the lower ones dentate .... *D. laevigata*.

1. **Dasystoma virgínica** (L.) Britt. Smooth False Foxglove.

Glabrous and glaucous perennial with stout, usually branched stem, 3–6 ft. high. Leaves usually all petioled, the lower ones pinnatifid, 4–6 in. long, the upper ones pinnatifid or deeply incised. Flowers very striking; corolla pure yellow, glabrous outside, about 2 in. long, in leafy-bracted racemes. Capsule glabrous. In woods. July–September. Adams, Fairfield, Clarke, Cuyahoga, Fulton, and Wood Counties. (**Aureolaria flava** (L.) Farw., according to Pennell.)

2. **Dasystoma pediculària** (L.) Benth. Fernleaf False Foxglove.

A much branched, leafy annual or biennial, 1–4 ft. high, more or less glandular and viscid. Upper leaves sessile, the lower ones usually petioled, pinnatifid, 1–3 in. long. Corolla 1–1½ in. long, pubescent outside; calyx-lobes foliaceous, usually pinnatifid or incised. Capsule pubescent. In dry woods and thickets. August–September. Fulton County. (**Aureolaria pedicularia** (L.) Raf., according to Pennell.) Our two specimens belong to the variety A. ambigens (Fern.) Farw., densely glandular-hirsute.

3. **Dasystoma flàva** (L.) Wood. Downy False Foxglove.

Erect, usually simple, sometimes branched perennial, 2–4 ft. high, pubescent with a fine, grayish down. Leaves oblong, lanceolate, or ovate-lanceolate, usually opposite, entire, or the lower ones sinuate-dentate, or sometimes pinnatifid, 3–6 in. long, short-petioled, the upper ones much smaller and sessile, becoming bract-like. Corolla pure yellow, 1½–2 in. long, glabrous outside. Calyx and capsule pubescent. In dry woods and thickets. July–August. Eastern Ohio, as far west as Erie, Clarke and Adams Counties. (**Aureolaria virginica** (L.) Pennell.)

4. **Dasystoma laevigàta** Raf. Entire-leaf False Foxglove.

Simple or sparingly branched perennial, 1–3 ft. high, glabrous or nearly so, but not glaucous. Leaves lanceolate or ovate-lanceolate, 1½–4 in. long, usually petioled, the upper ones entire, the lower ones dentate or incised. Corolla yellow, glabrous without, hairy within, 1–1¾ in. long, the limb fully as broad. Capsule glabrous. In dry thickets. July–August. Jackson, Adams, Vinton, Hocking, Fairfield, and Highland Counties. (**Aureolaria laevigata** (Raf.) Raf., according to Pennell.)

14. **Agalìnis** Raf. Agalinis.

Erect, branching herbs, some shrubby, with opposite, entire, sessile leaves, and large, showy flowers in racemes or panicles, or solitary in the axils. Corolla slightly two-lipped, campanulate or funnelform, five-lobed. Stamens four, didynamous, included; filaments pubescent. Capsule ovoid or globose. Seeds numerous, mostly angled.

1. Pedicels shorter than or but slightly longer than the calyx; plants of moist ground .... 2.
1. Pedicels much longer than the calyx, usually exceeding the corolla; plants of dry ground .... 3.
2. Corolla ¾–1¼ in. long .... *A. purpurea.*
2. Corolla ½–¾ in. long .... *A. paupercula.*
3. Plants leafy; leaves flat, linear to lanceolate, ½–1½ in. long; pedicels often shorter than the subtending leaf-bracts .... *A. tenuifolia.*
3. Plants very slender; leaves few and distant, filiform or with revolute margins, three-eighths to five-eighths in. long; pedicels usually longer than the subtending bracts .... *A. skinneriana.*

1. **Agalinis purpùrea** (L.) Pennell. Large-flowered Agalinis.

Smooth or roughish annual, with slender stem, 1–2½ ft. high, and with long, rigid, widely spreading branches. Leaves narrowly linear, usually widely spreading, 1–2½ in. long, rarely with clusters in their axils, rough-margined. Flowers rose-purple or rarely white, ¾–1¼ in. long; pedicels shorter than or but slightly longer than the calyx; corolla much expanded above, often downy, the lobes all spreading. Capsule globose. In low ground, moist fields and meadows. August–October. Rather general.

2. **Agalinis paupércula** (Gr.) Britt. Small-flowered Agalinis.

Annual, glabrous or nearly so, 6–18 in. high, the whole plant very similar to the preceding species, but smaller, apparently intergrading with it. Leaves narrowly linear, ½–1 in. long. Corolla rose-purple, the lobes all spreading, ½–¾ in. long. Capsule globose-oblong. In bogs and low meadows. July–September. Stark, Ottawa, Logan, Champaign, and Gallia Counties.

3. **Agalinis tenuifòlia** (Vahl.) Raf. Slender Agalinis.

Glabrous annual with slender stem, 6–24 in. high; plant very leafy. Leaves flat, linear to lanceolate, acute, ½–1½ in. long. Flowers light rose-purple, spotted, rarely white, ⅝–¾ in. long, the two upper lobes ascending over the stamens and style; pedicels often shorter than the subtending leaf-bracts. Capsule globose or slightly obovoid. In dry woods and thickets. August–October. General. Our specimens include both the typical form and **A. tenuifolia macrophylla** (Hook.)

4. **Agalinis skinneriàna** (Wood) Britt. Skinner's Agalinis.

Very slender, roughish annual, 6–18 in. high. Leaves few and distant, ⅜–⅝ in. long, filiform or with revolute margins, commonly erect and appressed. Corolla light rose-purple or white, up to ½ in. in length; pedicels usually longer than the subtending leaf-bracts. Capsule oblong. In dry, sandy woods and thickets. August–October. White-flowered form from southeastern part of Fulton County.

15. **Otophýlla** Benth. Otophylla.

Annual, hirsute-pubescent herbs, with opposite, sessile, entire or pinnately-divided leaves, all or some of them auricled at the base. Flowers purple or white in terminal spikes.

Corolla-tube broadly dilated at the throat; lobes spreading. stamens four, didynamous, included; filaments glabrous or nearly so; anthers awnless, those of the shorter stamens much smaller than the others. Seeds angled.

1. **Otophylla auriculàta** (Mx.) Small. Auricled Otophylla.

Rough-hairy annual, with slender and usually simple stem, 1–2 ft. high. Leaves 1–2 in. long, lanceolate or ovate-lanceolate, acuminate at the apex, sessile, the lower leaves usually entire, the others entire but commonly with a short, oblong-lanceolate lobe on each side at the base. Flowers solitary in the upper axils, purple, sessile, about 3/4 in. long, densely puberulent outside, glabrous within. Filaments glabrous or sparingly hairy; anther-sacs very unequal. In moist, open soil, low grounds, and prairies. July–September. Ottawa County.

16. **Búchnera** L. Blue-hearts.

Erect, hispid or scabrous perennials or biennials, mostly with opposite leaves and large, white, blue, or purple flowers in dense, terminal, bracted spikes. Corolla salverform; tube somewhat curved; lobes five, somewhat unequal, spreading. Stamens four, didynamous, included; anther-sacs confluent. Capsule oblong. Seeds numerous, reticulated.

1. **Buchnera americàna** L. Blue-hearts.

Perennial; stem slender, stiff, hispid and rough, 1–2½ ft. high. Leaves prominently veined, usually all opposite, the lower ones obovate or oblong, obtuse, narrowed into short petioles or sessile, sparingly and coarsely toothed, the upper ones lanceolate or linear-lanceolate, entire or nearly so. Spike peduncled, 6–10 in long in fruit; flowers mostly opposite, about 1 in. long; subtending bractlets shorter than the calyx; corolla purple, its lobes obovate, obtuse. Capsule oblique, a little longer than the calyx. In sandy or gravelly soil. June–September. Fulton County.

17. **Leptándra** Nutt. Culver's-root. (**Veronicastrum** Heist.)

Tall, erect, perennial herbs, with verticillate or opposite leaves. Flowers small, blue or white, in dense, spike-like racemes. Calyx 4-parted. Corolla tubular or salverform, four-lobed, only slightly two-lipped. Stamens two, much exserted. Seeds numerous, oval, minutely reticulated.

1. **Leptandra virgínica** (L.) Nutt. Culver's-root.

Perennial, with simple, erect stem, 2–7 ft. tall, glabrous or nearly so. Leaves verticillate, or some of the uppermost opposite, lance-shaped, finely serrulate, 3–6 in. long, 1/2–1 in. wide. The small, white or nearly white flowers are in dense, spike-like racemes, 3–9 in. long. In woods, thickets, and open places. June–September. General. (**Veronicastrum virginicum** (L.) Farw.) Rhizome and roots used officially as medicine.

18. **Verónica** (Tourn.) L. Speedwell.

Chiefly herbs, with small, blue, pink, or white flowers, in terminal or axillary racemes or spikes, or solitary in the axils. Calyx usually four-parted, sometimes five-parted. Corolla wheel-shaped, the tube short, four-lobed, rarely five-lobed, the lower lobe commonly the narrowest. Stamens two, exserted, divergent, the anther-sacs confluent at the apex. Capsule flattened, obtuse or notched at the apex. Seeds numerous, smooth or rough.

1. Flowers in axillary racemes, their bracts small.......... 2.
1. Flowers solitary in the axils, the subtending bracts leaf-like and similar to the leaves, usually becoming smaller toward the top.............. 8.
2. Calyx 4-parted...3.
2. Calyx 5-parted, the upper point small, all the sepal points with bristles; leaves ovate to lanceolate, sessile; racemes compact and showy. *V. teucrium.*
3. Plants hairy; leaves ovate to obovate; species of dry soil.................4.
3. Plants glabrous or minutely glandular; if hairy, then the leaves linear or linear-lanceolate; species of low ground and brook margins, or aquatic...5.
4. Stem pubescent in 2 lines; leaves ovate, pointed; pedicels longer than the calyx... *V. chamaedrys.*
4. Stem hairy all over; leaves oval or obovate; pedicels shorter than the calyx... *V. officinalis.*
5. Leaves all short-petioled.................................... *V. americana.*
5. Leaves sessile and clasping, or only the upper or lowermost petioled.......6.
6. Leaves ovate-oblong or oblong-lanceolate.............. *V. anagallis-aquatica.*
6. Leaves lanceolate to linear..7.
7. Leaves linear or nearly so, three-eighths to five-eighths in. wide; pedicels not glandular; capsule much wider than long, strongly 2-lobed.. *V. scutellata.*
7. Leaves lanceolate, broadest near the base, or the lowest elongated, lanceolate, clasping, five-eighths to one in. wide; rachis and pedicels sparsely pubescent with glands; capsule broad, globose, emarginate.... *V. glandifera.*
8. Pedicels shorter than the subtending bracts...........................9.
8. Pedicels longer than the subtending bracts...........................11.
9. Corolla white or pale blue, sometimes streaked with dark blue; leaves of the oblong type, glabrous or short-pubescent; calyx and bracts glabrous or slightly short-pubescent...10.
9. Corolla dark blue; leaves of the ovate type, 5–7 palmately nerved; long glandular-pubescent, including the bracts and calyx; annuals... *V. arvensis.*
10. Pedicels equalling the calyx; stem glabrous or pubescent; flowers in narrow racemes, more or less peduncled, the bracts becoming abruptly smaller than the uppermost foliage leaves; perennials .... *V. serpyllifolia.*
10. Pedicels much shorter than the calyx; stem glabrous or short-pubescent; corolla white or very pale blue; annuals...................... *V. peregrina.*
11. Sepals not heart-shaped at maturity, prominently veined; leaves of the ovate or oblong type; rather short petioles; leaves crenately cut-toothed. 12.
11. Sepals heart-shaped at maturity, without prominent veins; leaves of the orbicular type or very broad, 3–5 lobed or 3–5 crenate; rather long petioles... *V. hederaefolia.*
12. Corolla not longer than the calyx........................... *V. agrestis.*
12. Corolla longer than the calyx.............................. *V. tournefortii.*

1. **Veronica teùcrium** L. Germander Speedwell.

Pubescent perennial, with erect stem, up to 20 in. high. Leaves ovate to linear-lanceolate, nearly entire, crenate to even bluntly dentate-incised, mostly sessile. Racemes opposite, elongated, many-flowered; flowers large, blue or violet, rarely rose or white; calyx-segments oblong-linear to lanceolate. Capsule obovate. Rare in grass or waste land. August. Medina County. From Europe.

2. **Veronica chamaèdrys** L. Bird's-eye Speedwell.

Simple or branched perennial, with slender, ascending stem, pubescent in 2 lines, 4–12 in. high. Leaves ovate, sessile or nearly so, pubescent, truncate, rounded, or cordate at the base, incised-dentate, obtuse at the apex, $\frac{1}{2}$–$1\frac{1}{4}$ in. long. The loose racemes, 2–6 in. long, are long-peduncled, 10–20 flowered, and either in opposite or alternate axils; flowers light blue or violet-blue, about $\frac{3}{8}$ in. broad; pedicels longer than the calyx, and usually longer than the subtending bractlets. Capsule obcordate, narrowed at the base. In fields and waste places. May–July. Lake County. From Europe.

3. **Veronica americàna** Schwein. American Speedwell.

Glabrous perennial, at first decumbent, later erect and branching, rooting at the lower nodes, 6 in.–3 ft. long. Leaves oblong or oblong-lanceolate, short-petioled, sharply serrate, truncate, rounded, or sub-cordate at the base, 1–3 in. long, $\frac{1}{4}$–1 in. wide. Racemes loose, elongated, sometimes 6 in. long, usually 10–25 flowered, peduncled, and in most of the axils; bractlets shorter than the pedicels; flowers blue or nearly white, usually striped with purple. Capsule nearly orbicular, compressed. In brooks and swamps. Plant emersed. April–October. General.

4. **Veronica anagállis-aquática** L. Water Speedwell.

Perennial, with stout stem, glabrous or glandular-puberulent above, erect or decumbent, usually branched, often rooting at the lower nodes, 1–3 ft. high. Leaves of the sterile, autumnal shoots orbicular to obovate, serrulate, narrowed into margined petioles; leaves of the flowering stems lanceolate to oblong, $1\frac{1}{2}$–4 in. long, $\frac{1}{4}$–2 in. wide, sessile and more or less clasping, or the lowest ones short-petioled, finely serrate or nearly entire. Racemes 2–6 in. long, peduncled; flowers blue, often purple-striped. Capsule nearly orbicular, 2–lobed. In brooks and swamps. May–September. Butler, Champaign, Auglaize, Lucas, Erie, Miami, Clark, and Highland Counties.

5. **Veronica scutellàta** L. Skullcap Speedwell.

Perennial, usually glabrous, sometimes pubescent or hairy. Stem slender, decumbent or ascending, leafy, simple or branched, 6 in.–2 ft. high. Leaves sessile, slightly clasping, linear or linear-lanceolate, remotely denticultae, 1–$3\frac{1}{2}$ in. long, $\frac{1}{8}$ to nearly $\frac{5}{8}$ in. wide. Racemes axillary, equalling or longer than the leaves; peduncles slender; flowers small, blue, scattered, on very slender, spreading pedicels; bractlets shorter than the pedicels. Capsule much wider than long, strongly

2-lobed. In brooks and swamps. May–September. Cuyahoga, Ottawa, Erie, Perry, Lucas, Crawford, Licking, and Franklin Counties.

6. **Veronica officinàlis** L. Common Speedwell.

Pubescent perennial, with prostrate but finally erect stem, 3–12 in. high. Leaves oblong, oval, or obovate, ½–2 in. long, obtuse, serrate, narrowed at the base into short petioles. Racemes spike-like, narrow, dense, elongated, and axillary, much longer than the leaves; bractlets longer than the pedicels; flowers pale blue, striped with violet. Capsule obovate-cuneate. In dry fields and on hills. May–August. General and abundant. In colonial times grown as a medicinal plant.

7. **Veronica serpyllifòlia** L. Thyme-leaf Speedwell.

Perennial, glabrous or puberulent, with slender, branching stem, 2–10 in. high. Leaves oval, ovate, or oblong, crenulate or entire, short-petioled, or the uppermost sessile. Flowers in short, narrow, loose racemes, at the end of stem or branches; bractlets leaf-like, becoming abruptly smaller than the uppermost leaves; pedicles shorter than the bracts; corolla whitish or blue, with deeper stripes. Capsule rounded, obcordate or emarginate at summit, broader than high. Fields, lawns, roadsides, and thickets. April–August. General.

8. **Veronica peregrìna** L. Purslane Speedwell.

Erect, glabrous or glandular-puberulent, branching annual, 3–13 in. high. Leaves oblong, oval, linear, or only slightly spatulate, ¼–¾ in. long, the lowest ones opposite, sessile, usually denticulate, the upper ones alternate, sessile, mostly entire, longer than the flowers. Flowers solitary, axillary, usually white or very pale blue; pedicels shorter than the calyx. Capsule nearly orbicular, usually a little shorter than the calyx, glabrous. Waste and cultivated grounds, in damp soil. May–October. General. Our specimens include the glandular-pubescent form. **V. peregrina xalapensis** (H. B. K.) Pennell.

9. **Veronica arvénsis** L. Field Speedwell.

Simple or diffusely-branched, pubescent annual, 3–11 in. long. Lower leaves opposite, oval or ovate, crenate, the lowest ones petioled, the uppermost sessile, alternate, ovate or lanceolate, commonly entire. Flowers small, dark blue, solitary in the axils; pedicels shorter than the calyx. Capsule broadly obovate, obcordate. Fields, lawns, and woods, and cultivated soil. March–September. General. From Europe.

10. **Veronica agréstis** L. Garden Speedwell.

Slender, pubescent annual, with creeping or procumbent stem, 3–8 in. long, and ascending or spreading branches. Leaves broadly ovate, obtuse at the apex, truncate or subcordate at the base, crenate, short-petioled, the lower ones opposite, the upper ones alternate. Flowers small, blue, solitary in the axils, long-peduncled, the peduncles equalling or longer than the leaves. Corolla not longer than the calyx. Capsule broader than high, not very flat, narrowly emarginate at the summit. In fields and waste places. May–September. Hamilton, Montgomery, and Franklin Counties. From Europe.

11. **Veronica tournefórtii** Gmel. Tournefort's Speedwell.

Diffusely-branched, pubescent annual, 6–18 in. long. Leaves oval or ovate, short-petioled, crenate-dentate, $\frac{3}{8}$–$1\frac{1}{8}$ in. long, the lower ones opposite, the upper ones alternate. Flowers blue, comparatively large, on slender peduncles, solitary in the axils of the upper leaves; peduncles as long as or longer than the leaves; petals exceeding the sepals. Capsule twice as broad as high, with a wide, shallow indentation at the summit. In waste places. May–September. Madison, Franklin, Jefferson, Lorain, Cuyahoga, Lake, and Belmont Counties. From Europe.

12. **Veronica hederaefòlia** L. Ivy-leaf Speedwell.

Slender, diffusely-branched, pubescent annual, 3–18 in. long. Leaves broadly cordate, 3–5 lobed, 3–5 crenate, petioled, $\frac{1}{4}$–1 in. wide, the lower ones opposite, the upper ones alternate. Flowers small, blue, axillary, peduncled, the peduncles often longer than the leaves; corolla scarcely longer than the calyx; sepals densely ciliate, becoming heart-shaped at maturity. Capsule only slightly 2-lobed, scarcely notched at the apex, but little compressed. In thickets, fields, and waste places. Erie and Hamilton Counties. From Europe.

19. **Sýnthyris** Benth. Synthyris.

Perennial herbs, with simple, erect stems and a thick rhizome, with alternate leaves, the basal leaves large and petioled, the upper stem leaves smaller, sessile or partly clasping and bract-like. Flowers small, pink, purple, or greenish-yellow, in dense, elongated spikes or racemes. Corolla 2-4-lobed or cleft, or sometimes wanting. Stamens two, sometimes four, exserted; anther-sacs parallel or divergent. Seeds numerous, flat, oval or orbicular.

1. **Synthyris búllii** (Eat.) Heller. Bull's Synthyris.

Pubescent perennial, with a stout stem, 1–$2\frac{1}{2}$ ft. high. Basal leaves ovate or orbicular, rounded at the apex, truncate or cordate at the base, crenulate, 2–5 in. long, 5–7 nerved, with petioles usually shorter than the blades; stem leaves small, crenulate, sessile or slightly clasping, gradually becoming smaller. Inflorescence a dense spike, elongating in fruit; flowers small, greenish-yellow; the corolla, if present, commonly 2-lobed. Capsule emarginate, slightly exceeding the calyx. On dry prairies. May–July. Montgomery County.

20. **Pediculàris** (Tourn.) L. Lousewort.

Erect herbs, with pinnately-lobed, cleft, or pinnatifid leaves, and rather large flowers in spikes or spike-like racemes. Corolla strongly two-lipped, the upper lip arched, laterally compressed and often beaked at the apex, enclosing the four didynamous stamens. Anther-sacs similar and parallel. Ovules and seeds numerous.

1. Leaves partly opposite; leaf-blades deeply toothed or somewhat pinnatifid; upper lip of corolla truncate. Aug.–Oct. . . . . *P. lanceolata.*
1. Leaves scattered; leaf-blades pinnately-parted; upper lip of corolla with 2 lateral teeth. Apr.–June . . . . *P. canadensis.*

1. **Pedicularis lanceolàta** Mx. Lanceleaf Lousewort.

A stout, erect, usually simple perennial, 1–3 ft. high, glabrous or nearly so. Leaves mostly opposite, lanceolate, or linear-lanceolate, 2–5 in. long, finely cut. Spikes short; calyx 2-lobed, with foliaceous margins; corolla pale yellow, about ¾ in. long. Capsule ovate, scarcely longer than the calyx. Swampy places. August–October. Rather general, but no specimens from south of Montgomery and Hocking Counties.

2. **Pedicularis canadénsis** L. Wood Lousewort.

Pubescent or hirsute perennial, 6–18 in. high, with simple stem, commonly tufted, the whole plant more or less tinged with purple. Basal leaves clustered, 9–14 in. long, slender-petioled. Stem leaves scattered, 3–5 in. long, decurrent; leaves of the inflorescence gradually reduced to bracts. Flowers in short, terminal, dome-shaped spikes; calyx cleft on the lower side, with several tooth-like lobes on the upper side; corolla pale greenish-yellow, the upper lip tinged with brown or brownish-purple, ⅞–1 in. long. Inflorescence decidedly elongating in fruit, 5–12 in. long; capsule flat, about twice as long as the calyx. Hillsides and thickets. April–June. General.

21. **Castillèja.** Mutis. Painted-cup.

Erect herbs, parasitic on the roots of other plants, with alternate leaves and usually brightly-colored, inflorescence bracts. Flowers in spikes or racemes. Calyx laterally compressed, deeply cleft above or also below. Corolla decidedly zygomorphic and two-lipped, the upper lip arched and enclosing the four didynamous stamens. The two lobes of the anther unequal, the outer attached to the filament at the middle, the inner one by its apex. Capsule ovoid or oblong, many-seeded.

1. **Castilleja coccínea** (L.) Spreng. Scarlet Painted-cup.

Annual or commonly biennial, villous-pubescent, rather slender plant, 1–2 ft. high. Stem leaves prominently parallel-veined, divided into 3–5 linear, obtusish segments, sessile; the basal leaves in a rosette, parallel-veined or some at least, with two prominent side ribs from the base, entire. Inflorescence bracts 3–5 cleft, the lower green, the upper ones orange-scarlet, very conspicuous. Corolla ¾–1 in. long, greenish-yellow, the three lower lobes plicate. Ovulary with a green gland and prominent protuberance at its base. Moist meadows and hillsides. May–July. Franklin, Knox, and Madison Counties.

22. **Melampỳrum** (Tourn.) L. Cow-wheat.

Erect, branching, annual herbs with opposite leaves, and small flowers solitary in the axils or in terminal, bracted racemes. Calyx four-toothed, the two upper ones somewhat longer. Corolla two-lipped, the upper lip arched, compressed, enclosing the four didynamous stamens. Capsule flat, oblique, 2-4-seeded; seeds smooth.

1. **Melampyrum lineàre.** Lam. Narrow-leaf Cow-wheat.

A delicate annual with a slender, puberulent, wiry, somewhat 4-sided stem, 6 in.–1½ ft. high. Leaves light green, opposite, short-petioled, the floral ones with bristle-pointed teeth near the base or entire, the lower ones lanceolate or linear-lanceolate to ovate, 1–2½ in. long, ¼ in. wide. Flowers about ½ in. long, short-peduncled; corolla white and yellow, puberulent. In dry woods and thickets. May–August Lorain, Cuyahoga, Lake, Ashtabula, Geauga, Portage, and Hocking Counties.

23. **Antirrhìnum** (Tourn.) L. Snapdragon.

Annual or perennial herbs, with mostly opposite, entire leaves, and large, showy flowers in terminal racemes or solitary in the upper axils. Corolla decidedly saccate or gibbous on the lower side, with a prominent palate closing the throat. Andrecium with four didynamous, anther-bearing stamens, included, the lateral pair longer, and a very minute, sterile, fifth stamen. Capsule many-seeded.

1. **Antirrhinum màjus** L. Great Snapdragon.

Perennial, 1–3 ft. high, glabrous except near the inflorescence, which is usually more or less glandular-pubescent. Leaves lanceolate, linear, or oblong-lanceolate, entire, acute at both ends, short-petioled, 1–3 in. long. The flowers are of a variety of colors ranging from white, pale yellow, and pink, to very deep orange, brown, and purplish-red, 1–2 in. long, arranged in simple racemes, 3–12 in. long. Style and ovulary covered with glandular hairs. The fifth or vestigial stamen very small and 2-lobed. Sparingly escaped from gardens. June–September. Madison and Highland Counties. From Europe.

24. **Linària** (Tourn.) Mill. Toadflax.

Herbs, or somewhat shrubby plants, with alternate leaves, or the lower opposite or verticillate, and flowers in terminal, bracted spikes or racemes. Corolla two-lipped, usually spurred on the lower side, its throat nearly closed by the palate. Stamens four, didynamous, included. Seeds numerous, angled or rugose.

1. Flowers yellow, ¾–1¼ in. long; spur of corolla subulate, nearly as long as the body . . . . *L. linaria.*
1. Flowers blue to white, ¼–½ in. long; spur of the corolla filiform. *L. canadensis.*

1. **Linaria linària** (L.) Karst. Yellow Toadflax.

A very common but beautiful perennial, with slender, erect, glabrous stems, sometimes glandular-pubescent above, and slightly glaucous, 1–3 ft. high. Leaves linear, pale green, entire, ½–1½ in. long, about ⅛ in. wide, mostly alternate, but growing close together on the stems. Flowers pale yellow with darker spur and orange-colored palate, about 1¼ in. long, crowded in dense racemes. Capsule ovoid. Seeds rugose, winged. In fields and waste places. June–October. General, but no specimens from the north-western counties. From Europe. Commonly called Butter-and-Eggs. Used in medicine; flowers used as a dye.

2. **Linaria canadénsis** (L.) Dum. Blue Toadflax.

Glabrous biennial or annual, 6 in.–2½ ft. high, the flowering stems erect or ascending, the sterile shoots spreading or procumbent, and very leafy. Leaves linear or linear-oblong, ¼–1¼ in. long, ⅛ in. wide, those on the sterile shoots usually opposite. Flowers blue or white, ¼–⅜ in. long, in long, slender racemes; spur of corolla filiform, curved, as long as the tube or longer; palate white. Seeds angled, wingless. In dry or sandy soil. May–September. Richmond Township, Huron County.

25. **Chaenorrhìnum** (D. C.) Lange. Toadflax.

Herbs, with alternate, usually entire leaves, and blue, violet, or white, axillary flowers. Corolla two-lipped, definitely spurred on the lower side, the throat not closed by the palate. Stamens four, didynamous. Capsule inequilateral, one carpel longer than the other. Seeds ovoid or cuneate, ribbed.

1. **Chaenorrhinum mìnus** (L.) Lange. Lesser Toadflax.

Annual, glandular-pubescent all over, often branched, 5–13 in. tall. Leaves linear-spatulate to linear, mostly obtuse, narrowed at the base, ½–1¼ in. long. Flowers blue or bluish, about ⅜ in. long, shorter than the pedicels; spur short and stout, much shorter than the body of the corolla. Capsule globose-ovoid. Waste grounds and ballast. August–October. Portage, Huron and Belmont Counties. From Europe.

26. **Kíckxia.** Dum. Cancerwort.

Spreading or creeping herbs, with pinnately-veined, short-petioled leaves, and solitary, white, yellow, or variegated, axillary flowers. Corolla two-lipped, spurred on the lower side, the throat closed by the palate. Stamens four, didynamous. Seeds numerous, ovoid, mostly rough or tubercled.

1. Leaves cordate or rounded at the base, ovate-orbicular; corolla spur curved. *K. spuria*
1. Leaves hastate; corolla spur straight . . . . *K. elatine.*

1. **Kickxia spùria** (L.) Dum. Roundleaf Cancerwort.

Pubescent annual, with simple or branched, prostrate stems, 3 in.-2 ft. long. Leaves ovate-orbicular, entire, or sometimes dentate, cordate or rounded at the base, 1/4-1 in. long, with short petioles. Flowers small, solitary in the axils; peduncles very pubescent, often much longer than the leaves; corolla yellowish, the upper lip purple; spur curved; calyx-lobes ovate or cordate. Capsule subglobose, shorter than the calyx; seeds rugose, not winged. In waste places and ballast. June–September. Lake County. From Europe.

2. **Kickxia elatìne** (L.) Dum. Sharp-pointed Cancerwort.

Pubescent annual, with prostrate stems, usually branched, 6 in.-2 ft. long. Leaves 1/2-1 in. long, short-petioled, the apex acute, the base hastate or subcordate. Flowers small, solitary in the axils; peduncles glabrous, or somewhat hairy, filiform, usually longer than the leaves; calyx-lobes lanceolate, acute; corolla yellowish, purplish beneath; spur slender, straight. Capsule subglobose, shorter than the calyx; seeds wingless. In sandy waste places. June–September. Lake County. From Europe.

27. **Cymbalària.** Kenilworth-ivy.

Perennial, creeping herbs, with long-petioled, palmately-veined leaves, and solitary, long-peduncled, bluish, violet, or white flowers, in the axils. Corolla two-lipped, definitely spurred on the lower side, the throat nearly or quite closed by the palate. Stamens four, didynamous, included. Seeds numerous, small.

1. **Cymbalaria cymbalària** (L.) Wettst. Kenilworth-ivy.

A dainty perennial, with smooth, trailing stem, 3 in.–4½ ft. long, often rooting at the nodes. Leaves reniform-orbicular, ¼– .1 in. in diameter. Petioles usually as long or longer than the blade. Corolla pale lilac or white, streaked with purple, ¼–½ in. long, the palate yellowish. In waste places and along roadsides. June–August. Montgomery, Crawford, Highland, Cuyahoga, Fulton Counties. From Europe.

28. **Calceolària** L. Calceolaria.

Tender herbs or shrubs, mostly with opposite leaves, a four-parted calyx, and a two-parted corolla, the two lips sack-shaped. Flowers in cymes or clusters. Andrecium with two stamens and no vestiges.

1. **Calceolaria crenatiflòra** Cav. Calceolaria.

Herbaceous, soft-hairy plant, with simple leaves, and yellow, variously-spotted flowers. Corolla 2¼ in. broad, 1¾ in. long. This species is apparently the main source of the more showy, herbaceous, garden varieties and hybrids. Cultivated.

A REVISION OF THE RACES OF DENDROICA AUDUBONI.

Harry C. Oberholser.
Washington, D. C.

Identification of Arizona specimens of *Dendroica auduboni* in the collection of the Biological Survey has made necessary this investigation into the geographical forms of the species. As these results are of some interest, it may be well to place them on permanent record.

Three subspecies of *Dendroica auduboni* have hitherto been recognized—*Dendroica auduboni auduboni*, *Dendroica auduboni nigrifrons*, and *Dendroica auduboni goldmani*—but to this number another should apparently now be added. The following conclusions are based chiefly on the considerable series (248 specimens) in the United States National Museum, including the Biological Survey collection, and comprising types of three of the forms here recognized. The type of the fourth, *Dendroica nigrifrons* Brewster, has also been examined.

Dendroica auduboni auduboni Townsend.

S[*ylvia*]. *Auduboni* Townsend, Journ. Acad. Nat. Sci. Phila., Ser. 1, VII, pt. ii, November 21, 1837, p. 191 ("forests of the Columbia River").

Chars. Subsp.—Size smallest, and with a minimum extent of black on the lower parts.

Measurements.—Male:[1] wing, 71.5–77 (average, 74.9) mm.; tail, 55–60 (58.2); exposed culmen, 9.5–10.8 (10.3); tarsus, 18.5–20 (18.6); middle toe with claw, 10–12.8 (11.8).

Female:[2] wing, 69.8–73.8 (average, 71.6) mm.; tail, 55.5–58 (56.6); exposed culmen, 10–11 (10.3); tarsus, 19–19.8 (19.3); middle toe with claw, 10.5–12.5 (11.6).

Type Locality. Columbia River, near Fort Vancouver, Washington.

Geographic Distribution. Central British Columbia, through the western United States, to southwestern Mexico. Breeds north to central British Columbia; west to Vancouver Island in British Columbia, western Washington, western Oregon, and western California; south to southern California;

[1] Ten specimens, from Oregon. Washington, and British Columbia.
[2] Six specimens, from Washington and British Columbia.

and east to central eastern California, central Oregon, central Washington, and central British Columbia. Winters from southern British Columbia, south through California and Arizona, to the States of Guanajuato and Michoacan, Mexico. In migration it occurs casually east to Wyoming and New Mexico.

REMARKS. The type of Townsend's *Sylvia auduboni* was an adult male obtained by him on the Columbia River near Fort Vancouver, and is now in the United States National Museum. It proves to belong to the smallest race of the species, so that the specific name *auduboni* applies without doubt to the breeding bird of the Pacific coast region of the United States. This subspecies reaches its minimum size in Washington and British Columbia. Average wing measurements of adult males from different localities compare as follows: Washington and British Columbia, 74.9 mm.; California, 76.6 mm. Individuals from central Oregon and from California (excepting the southeastern portion of the state) are somewhat intermediate between typical *Dendroica auduboni auduboni* and the Rocky Mountain race, but are evidently nearer the present form.

The 116 specimens examined came from the following localities:

British Columbia.—Comox (May 31, 1895; June 1 and 8, 1895); Stuart Lake (June 4, 1889; eggs and nest); Wellington (May 25, 1895); Agassiz (Dec. 7, 1895).

Arizona.—Fort Verde (Jan. 23, 1888; Dec. 30, 1887); Apache (Oct. 26 and 29, 1874); Cochise (May 5, 1902); Tucson (Jan. 29, 1884).

California.—San Francisco (Oct. 29, 1895); San Bernardino (Jan. 5, 1886); Red Bluff (Dec. 22, 1883; May 6, 1884; April 7 and 25, 1884; March 29, 1884); Warner Mountains (Aug. 9, 1878); Poway (Feb. 24, 1888); Nevada (October, 1872); Berryessa, Santa Clara Co. (Jan. 20, 1889; April 4, 1890); Santa Clara County (Oct. 5, 1896); Lassen Peak (Aug. 26, 1898); Chico (Dec. 21, 1905; Jan. 5, 1906); Burney (June 9, 1906); South Yolla Bolly Mountain (July 29, 1905); Oro Grande (March 18, 1905); San Diego (Oct. 9, 1893); Riverside (Jan. 2, 1889); Carberry's Ranch (May 20, 1894); Strange Camp, 5800 feet, San Gabriel Mountains (July 16, 1905); Preston

Peak, northeastern slope of Siskiyou Mountains (Oct. 7, 1909); Cahto (May 6, 1889); Los Angeles County (Feb. 13, 1915); Camp Bidwell (July 24, 1878); Big Trees (July 7, 1878); Picard (Sept. 27, 1905); Mount Shasta (July 24, 1883; Aug. 10, 1898; Aug. 26, 27, and 31, 1883; Sept. 2, 1883); Sacramento Valley.

Nevada.—Arc Dome (May 22, 1898).

New Mexico. — Corner Monument No. 40, Mexican Boundary Line, 100 miles west of El Paso (May 3 and 5, 1892).

Oregon.—Beaverton (April 24, 1890); Portland (May 24 and 25, 1905); Lapush (June 12, 1897); Salem (March 25, 1888; Sept. 22, 1891); Fort Klamath (Sept. 5 and 6, 1882; Oct. 1, 9, and 13, 1882; July 16, 1882); Howard (June 10, 1915); Paulina Lake (Aug. 18, 1914); Home (June 27, 1916); 10 miles S. W. of Silver Lake (Sept. 2 and 4, 1914); Fremont (Aug. 23, 1914).

Washington.—Kirkland (May 11 and 18, 1911); Columbia River (April 24, 1836, type; April, 1836; May 31, 1835); Fort Steilacoom (about April 1, 1856; July 28, —); Steilacoom; Mt. St. Helens (Aug. 11, 1897).

Wyoming.—Fort Bridger (Aug. 27, 1858).

Chihuahua.—Chihuahua City (Oct. 21, 1893).

Guanajuato.—Guanajuato.

Jalisco.—Ocotlan (Dec. 24, 1902); Tonila (October, 1865).

Lower California.—La Laguna (Jan. 26, 1906); El Sauz, Sierra Laguna (Jan. 21, 1906); San Jorge (Nov. 25, 1859); Gardiner's Laguna, Salton River (April 20, 1894); Seven Wells (April 15, 1894); Mouth of Colorado River; La Paz (December, 1881); Mouth of Hardy River (April 2, 1905).

Michoacan.—Zamora (Jan. 20, 1903); Mt. Tancitaro (March 3, 1903).

San Luis Potosi.—San Luis Potosi (Feb. 3, 1891).

Sinaloa.—Sierra de Choix, 50 miles northeast of Choix (Oct. 19, 1898).

Sonora.—Sonoyta (Jan. 14, 1894); Guaymas; Taronato Creek, near U. S. and Mexican boundary line (Nov. 4, 1892).

Tepic.—Maria Cleofa Island, Tres Marias Islands (May 30, 1897); Tepic (December, 1865).

Dendroica auduboni memorabilis, subsp. nov.

CHARS. SUBSP.—Similar to *Dendroica auduboni auduboni*, but larger; male with breast and jugulum nearly always more solidly and extensively black; and sides of head also with more of blackish.

DESCRIPTION.—Type, adult male; No. 137415, U. S. National Museum, Biological Survey Collection; Ward, Colorado, June 12, 1893; J. A. Loring. Upper parts between neutral gray and slate gray, the forehead and sides of crown thickly, the cervix sparingly, the interscapulum broadly, streaked with black; upper tail-coverts black, edged with the gray of the back; center of crown gamboge yellow; rump lemon chrome; tail brownish black, narrowly margined exteriorly with gray like that of the back or with whitish; wings rather light chaetura black, the tips of the quills dark fuscous, the secondaries edged and tipped with mouse gray, the primaries with pale gray or whitish; superior wing-coverts black, the median series broadly tipped, the greater series broadly tipped and margined externally with white, the lesser coverts margined and tipped with the gray of the back; sides of head and of neck gray like the back, the latter, together with the auriculars, flecked with black; a spot in front of the eye and of the suborbital region black; upper and lower eyelids white; throat and chin, gamboge yellow; jugulum and sides of breast, black, a little flecked laterally with the gray of the back; a spot on each side of the breast lemon chrome; remainder of lower parts white, the sides and flanks broadly streaked with black; lining of wing white, the under wing-coverts mottled with brownish black.

MEASUREMENTS.—Male:[1] wing, 77.3–83.5 (average, 80.5) mm.; tail, 60–66.8 (63); exposed culmen, 9.5–11 (10.3); tarsus, 18–21 (19.6); middle toe with claw, 10.3–13.2 (11.9).

Female:[2] wing, 72–78 (average, 74.5) mm.; tail, 55–61 (58.1); exposed culmen, 9.5–11 (10.1); tarsus, 18–20 (19.2); middle toe with claw, 11–12.2 (11.7).

TYPE LOCALITY.—Ward, Boulder County, Colorado.

GEOGRAPHIC DISTRIBUTION. — Central southern Canada, western United States, Mexico, and Guatemala. Breeds north to southwestern Saskatchewan and central Alberta; west to eastern Washington, eastern Oregon, central Nevada, and southeastern California; south to southeastern California, central Arizona, southeastern Arizona, and central western Texas; and east to central western Texas, central New Mexico, central Colorado, northwestern Nebraska, eastern Wyoming, western South Dakota, and central Montana. Winters north to southern California, southern New Mexico, and south

[1] Fifteen specimens, from Arizona, New Mexico, Colorado, and Montana.
[2] Twelve specimens, from Arizona, New Mexico, Colorado, and Wyoming.

central Texas; south to southern Mexico and Guatemala. In migration it occurs east to Iowa. Accidental in Pennsylvania and Massachusetts.

REMARKS.—The best character separating this new race from *Dendroica auduboni auduboni* is that of size, although this is less marked in the female. There is considerable individual variation in the amount of black on the lower parts, but this is nearly always of greater extent than in *Dendroica auduboni auduboni.* Birds from Arizona and Montana are of the same size, and of practically the same coloration. Individuals from Nevada and Idaho are intermediate between *Dendroica auduboni memorabilis* and *Dendroica auduboni auduboni*, though they are nearer the present form. The same remarks apply also to breeding birds from the mountains in southeastern California near the State border, as, for instance, Mount Whitney. All the breeding birds from the mountains of Arizona, except those from the Huachuca Mountains, belong to the present race, but those from the southern part of the State verge a little toward *Dendroica auduboni nigrifrons.* Comparative wing measurements of adult males from different localities are as follows: Arizona and New Mexico, 80.3 mm.; Wyoming and Montana, 79.2 mm.; Idaho, 78.6 mm.

The 104 specimens that we have examined represent the localities given below.

Arizona.—Graham Mountains (April 24 and 25, 1914; May 12, 1914); Fort Verde (May 5 and 22, 1884; May 3, 1887; March 6, 1886); Pinal County (March 19, 1885; Oct. 28,1884); Nantan Plateau (May 15, 1916); Horseshoe Cienega, White River, White Mountains (July 9 and 15, 1915); Disaster Peak (June 14, 1915); Chiricahua Mountains (June 14, 1894); Camp 150, Coco Mengo Rancho (March 19, 1854); Apache (Oct. 26, 1874; Sept. 1, 1873); Mt. Graham, Graham Mountains (Sept. 21, 24, and 25, 1874; Oct. 29, 1874); San Pedro slope, Santa Catalina Mountains, Pinal County (May 6, 1885); Santa Catalina Mountains (June 10, 1906); Tucson (May 18, 1884; Nov. 18, 1890; April 13 and 19, 1884); Fort Whipple (May 5, 1865; May 8, 1866; Oct. 3, 1864; April 24, 1865; April 27, 1866); Yuma (March 10, 1894); Willow Spring (July 12 and 13, 1874); Monument No. 89, Mexican Boundary Line (Sept. 24, 1892); Sawmill, at 5,600 feet, 25 miles northeast of Rice (May 10,

1916); Tanks, 7 miles from Strawberry, Mogollon Mountains (July 3, 1886); Marsh Lake, White Mountains (July 20, 1915); Lakeside (July 5, 1915); Huachuca Mountains[1] (May 26, 1903; April 8, 24, and 27, 1903; Sept. 10 and 21, 1893).

California.—San Denias Canyon, Los Angeles Co. (Oct. 24, 1915); Riverside (April 16, 1887); Berryessa (Dec. 5, 1889); Cahto (May 15, 1889); Mount Shasta (Aug. 31, 1883); Oro Grande (March 22, 1905); Mendota (Oct. 2, 1907); Placerita Canyon, Los Angeles Co. (Dec. 10, 1915); Mt. Whitney (June 19, 1891; July 7, 1891); Santa Barbara (October, 1888); Laguna Station, San Diego Co. (May 5, 1874); Death Valley (Feb. 1, 1891); Fullerton (Dec. 4, 1900); Southern sierra Nevada (July 26, 1891).

Colorado.—Denver (May 7, 9, 10, and 17, 1873); Pueblo (Oct. 14, 1874); Estes Park (July 17, 1893).

Idaho.—Swan Lake (July 5 and 7, 1911); Lardo (July 18, 1913); Edna (June 21, 1910); Tamarack (July 6, 1913); Inkom (June 25, 1911); Idaho City (June 16, 1910).

Montana.—Chief Mountain Lake (Aug. 22, 1874); Jefferson River (Sept. 15, 1888); Sioux National Forest, 8 miles east of Sykes (June 2, 1916); Madison River (Sept. 23, 1888); 5 miles southeast of Ekalaka (May 28, 1916); 5 miles south of Ekalaka (May 28, 1916).

Nevada.—Lake Tahoe (Sept. 18, 1876); Toyabe Mountains (Aug. 16, 1915); Arc Dome, Toyabe Mountains (May 24, 1898); Carson City (April 4 and 18, 1868).

New Mexico.—Pecos (July 20, 1883); Tres Piedras (July 31, 1904); Aug. 1, 1904); Rinconada (May 3 and 31, 1904); Fort Cummings (Oct. 15 and 25, 1873); Gila River (Oct. 11, 1873); Corner Monument, No. 40, Mexican Boundary Line, 100 miles west of El Paso (May 3 and 5, 1892); Zuni Mountains (June 16, 1909); Camp Grant, 6 miles east of Tucson (March 10, 1867); Dog Spring, Grant Co. (May 24, 1892); Elizabethtown (Sept. 17, 1903); southwestern slope of Capitan Mountains (July 10 and 13, 1903); Big Hatchet Mountains, Grant Co. (May 18, 1892).

Oregon.—Strawberry Mountains (July 13, 1915).

South Dakota.—Hot Springs (Oct. 17, 1892); Redfern (June 2, 1910).

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[1] Not breeding.

Texas.—Fort Clark (April 6, 1893); Eagle Pass (Oct. 27, 1890); Henrietta (April 19, 1894); Fort Stockton (April 20, 1860); Marathon (May 15, 1901).

Utah.—Mouth of Bear River (May 23, 1915; Sept. 10, 1914).

Wyoming.—Teton Pass (Sept. 15, 1910); Laramie; Horse Creek, 8,000 feet, near Merna (Aug. 12, 1911); Casper Mountains (Aug. 28, 1909); Jackson (May 17, 1911); 14 miles southeast of Laramie (July 15, 1915); Fort Steele (May 22, 1911); Fremont Peak (July 18, 1911); Sierra Madre Mountains (June 16, 1911); Fort Bridger (May 20, 1858); western side of Wind River Mountains (June 6, 1860); Bridgers Pass (May 9, 1890); Laramie Peak (May 16, 1864); Pahaska (July 30, 1910); Medicine Bow Mountains (June 30, 1911); Fossil (May 7, 1912).

Chiapas.—[No further locality] (Jan. 24, 1869).

Chihuahua.—Colonia Pacheco (May 22, 24, and 31, 1909).

Coahuila.—Saltillo (April 17, 1902).

Guanajuato.—Guanajuato.

Hidalgo.—Real del Monte (May 5, 1891).

Lower California.—Comondu (Nov. 9, 1905); Ensenada (Feb. 27, 1906); Cape San Lucas (Nov. 12, 1859).

Mexico.—Salazar (Oct. 26, 1892); Tlalpam (Dec. 8, 1892).

Michoacan.—Patamban (Jan. 29, 1903); Mt. Tancitaro (March 4, 1903); Los Reyes (Feb. 8, 1903).

Nuevo Leon.—Monterey (Feb. 21 and 26, 1891).

Puebla.—Chalchicomula (April 13, 1893).

Sinaloa.—Mazatlan (December, 1867).

Sonora.—Mouth of Colorado River.

Yucatan.—Temax (1884).

Guatemala.—[No more definite locality].

Dendroica auduboni nigrifrons Brewster.

Dendroica nigrifrons Brewster, Descriptions of Supposed New Birds from Western North America and Mexico, Jan. 31, 1889. [The Auk, VI, No. 2, April, 1889], p. 94 ("Pinos Altos, Chihuahua, Mexico").

CHARS. SUBSP.—Similar to *Dendroica auduboni memorabilis*, but male with upper parts and sides of neck darker, the back with much more black, the forehead and sides of head entirely of this color; breast, jugulum, flanks, and sides of body solidly black; female darker than the

same sex of *Dendroica auduboni memorabilis*, with more black both above and below.

Measurements.—Male:[1] wing, 78–85.5 (average, 81.8) mm.; tail, 58–68 (62.8); exposed culmen, 10–10.5 (10.2); tarsus, 18.5–20 (19.4); middle toe with claw, 11.3–12.8 (12).

Female:[2] wing, 75–77.5 (average, 76.1) mm.; tail, 57–61 (58.5); exposed culmen, 9.5–10.8 (10.3); tarsus, 18.5–20 (19.3); middle toe with claw, 11.7–12.8 (12.2).

Type Locality.—Pinos Altos, Chihuahua, Mexico.

Geographic Distribution.—Southern Arizona and northwestern Mexico. Breeds north to the Huachuca Mountains in central southern Arizona, and southeast through western Chihuahua to southern Durango.

Remarks.—This race of the Audubon warbler occurs in the United States only in the Huachuca Mountains, Arizona. Birds of this species from all the other adjacent ranges are, as already explained, referable to *Dendroica auduboni memorabilis*. Those from the Huachuca Mountains are, furthermore, in color somewhat intermediate between *Dendroica auduboni nigrifrons* and *Dendroica auduboni memorabilis*, as would be expected from their geographic location, but are decidedly nearer the former. Comparative average wing measurements of males are as follows: Chihuahua, 81.3; Huachuca Mountains, Arizona, 82.3.

Of this subspecies 29 specimens have been available, from the subjoined localities.

Arizona.—Huachuca Mountains (Aug. 19, 26, and 30, 1902); July 1 and 13, 1902; July 31, 1893; May 11, 20, and 26, 1903; June 21, 1902; April 5, 1903; May 9, 1902).

Chihuahua.—Colonia Pacheco (June 3 and 9, 1909); Colonia Garcia (July 4, 1888; July 3, 9, and 24, 1899; Aug. 5, 1899); Pinos Altos (June 5, 1888, type).

Durango.—Cerro Prieto (Sept. 10, 1898); El Salto (July 11, 1898).

Dendroica auduboni goldmani Nelson.

Dendroica goldmani Nelson, The Auk, XIV, No. 1, January, 1897, p. 66 ("Hacienda Chancol, Guatemala").

[1] Nine specimens, from the State of Chihuahua, Mexico, and from Arizona.

[2] Eight specimens, from the States of Chihuahua and Durango, Mexico, and from Arizona.

CHARS. SUBSP.—Similar to *Dendroica auduboni nigrifrons*, but with still more black on the upper parts, the whole top and sides of head being solidly black (excepting, of course, the yellow crown space and the white cervical spot); flanks not solidly black; and black of posterior lower parts not so extensive; a large white spot on each side of the posterior border of the yellow throat; and white occipital patch much larger.

MEASUREMENTS.—Male: (type) wing, 83 mm.; tail, 66.2; exposed culmen, 10.6; tarsus, 20.7; middle toe with claw, 13.

TYPE LOCALITY.—Hacienda Chancol, at about 10,000 feet altitude, Huehuetenango, western Guatemala.

GEOGRAPHIC DISTRIBUTION.—Mountains of western Guatemala.

REMARKS.—The only specimen of this subspecies that, so far as we are aware, has been obtained is the type. Nevertheless in this the characters are such as indicate its subspecific distinctness from *Dendroica auduboni nigrifrons*, since the differences that characterize the latter as distinguished from *Dendroica auduboni memorabilis* are in *Dendroica auduboni goldmani* carried still further.

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STEEL MOLDING SAND IN OHIO.

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There are two types of molding sands, (1) those for steel castings and (2) those for iron castings. The difference between the two is primarily their refractory nature. Steel castings require a sand that will not melt below 2,900° Fahrenheit, while for iron castings 2,400° is sufficient.

Ohio is a leading producer of both grades of molding sand, but this article considers only those suitable for steel purposes. The chief requisites for a molding sand are refractory nature, strength when in mold, vent or porosity and the surface left on the castings. In steel casting, however, all of these properties except that of fusibility may be regulated by the sand producer or in the steel mill, and they need not, therefore, be discussed in this paper.

The minerals which compose the sandstones and conglomerates from which steel molding sands are made are numerous, but silica or quartz in some form constitutes 95 per cent or more of the mass. Other common minerals present are feldspar, mica, and oxide of iron. The fusion temperatures of these are about as follows:

Silica	2,678° F.
Orthoclase (feldspar)	2,167°
Hematite	2,206°[1]
Magnetite	2,507°[1]
Muscovite (mica)	2,246°

Manifestly as the proportion of silica increases the fusion point of the sand rises, while as the proportion of other common minerals grows larger the fusion point is lowered. A high silica percentage is therefore the first requisite of a sand for steel molding purposes.

[1] Hematite and magnetite have no definite melting temperatures.

In Ohio the steel molding sands are at present all derived from rocks of Pennsylvanian or Carboniferous age. These rocks are subdivided on the basis of their age as follows:

Pennsylvanian:
- Monongahela formation.
- Conemaugh formation.
- Allegheny formation.
- Pottsville formation.

At present only the Pottsville and Allegheny formations yield steel molding sand in Ohio, and the Pottsville is much the larger source.

MAP I.
This shows the outcrop of the Pottsville formation and the location of the plants which produce steel molding sands in Ohio.

THE POTTSVILLE FORMATION.

Since the Pottsville is the basal formation of the Pennsylvanian rocks, its line of outcrop lies along the junction of the Pennsylvanian and Mississippian systems. It is shown in detail on the Geologic Map of Ohio for 1920, and in a general way in Map I of this article. As there sketched it enters Ohio in Trumbull County, extends north nearly to Lake Erie, thence west of south to the Ohio River, which it reaches in Lawrence County.

The Pottsville formation, which has a thickness of about 225 feet in Ohio, consists of conglomerate, sandstone, shale, coal, clay, limestone and flint. The following section shows the principal members of the formation.

Homewood sandstone
    Tionesta or No. 3b coal
Upper Mercer limestone, flint and iron ore
    Bedford coal
Shales
    Upper Mercer or Webster Block or No. 3a coal
Lower Mercer limestone and iron ore
    Lower Mercer or No. 3 coal
Upper Massillon sandstone
    Quakertown or No. 2 coal
Clay and shale
Lower Massillon sandstone
    Sharon or No. 1 coal
Sharon conglomerate

THE SHARON CONGLOMERATE.

The Sharon conglomerate, the basal member of the Pottsville, is the main source of steel molding sand in Ohio. While called conglomerate, it varies greatly in its physical makeup and may be conglomerate, coarse sandstone or shale.

Where the rock is conglomeratic the pebbles are of quartz which vary in size from a small fraction of an inch up to three inches or even more. The color is usually of light shades. In places pink is common. Near the top of the rock, buff is the characteristic color, while below, light gray is the usual shade. In places dark brown patches, due to iron, were noted. The pebbles are well rounded and have smooth surfaces, which suggest abrasion, due to water action. The characteristic shape is oval. The proportion and size of pebbles vary rapidly

in places, both horizontally and vertically. Not infrequently they form pockets in coarse sandstone.

In thickness the Sharon conglomerate also shows marked variation due largely to the unevenness of its lower surface. G. F. Lamb reports the maximum thickness of the rock in northern Ohio to be 90 feet,[1] while in the southern part of the State, W. Stout records as much as 200 feet.[2] Thicknesses in excess of 50 feet are common in Trumbull, Geauga, Portage, Summit, Jackson, and doubtless in other counties. As a rule, the rock is poorly cemented and hence is easily crushed. Silica appears to be the chief bonding agent. The rock is massive and cross-bedding is common.

The base of the Sharon conglomerate is very uneven. Before it was deposited the underlying Mississippian rocks were extensively eroded and valleys 200 feet in depth were formed in places. Lamb states that in northern Ohio the Sharon is restricted to these valleys and that they have a north-south trend.[3] On such a surface the Sharon was deposited. The irregularity of this contact in the central and southern part of the State is well shown on Plate III of Bulletin 21, Geological Survey of Ohio. It forms the most striking unconformity in the State.

In northeast Ohio, all of the Mississippian above the Cuyahoga appears to have been removed by erosion, and the Sharon, therefore, rests directly on the Cuyahoga. In the central and southern part, however, the Sharon lies in many places on the Maxville limestone, the top of the Mississippian strata.[4] This indicates that before the Sharon was laid down there was more extensive erosion of the Mississippian rocks in the northern part of the State than there was in the southern part.

From what has been recorded concerning the thickness and length of outcrop of the Sharon in Ohio, it is apparent that the quantity of rock is enormous, and regardless of what use may be made of it, the supply is ample for centuries. Brief descriptions will now be given of the principal plants, and data on the chemical and mineralogical composition of the sand. For

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[1] Personal letter dated August 30, 1920.
[2] W. Stout, Bull. 20, Geol. Survey of Ohio, p. 42.
[3] G. F. Lamb, Jour. of Geol., Vol. 19, p. 105.
[4] W. Stout, Bull. 20, Geol. Survey of Ohio.

the chemical work the Geological Survey is indebted to Prof. D. J. Demorest, of the Ohio State University, and for the microscopical examination of the sands the Survey is equally indebted to D. D. Condit, formerly of the Geological Survey of Ohio and later of the United States Geological Survey.

The Trumbull Stone and Sand Company. This plant is about 5½ miles west of Warren, Trumbull County, on the Baltimore and Ohio Railroad. The company owns 105 acres and in 1920 was working about 45 feet of the Sharon conglomerate. Pebbles, the largest about 1¼ inches in diameter, were observed near the base of the quarry and were reported to be found occasionally above the base. The mass of the rock, however, is a coarse sandstone with a buff or light brown color.

The rock is loaded on cars with a steam shovel, hauled to the mill and crushed and screened to three grades of sand. No. 1 is used for furnace bottoms in steel and tube mills, No. 2 for steel castings and furnace bottoms, and No. 4 for lining Bessemer converters. The principal market is Lorain, Youngstown, Pittsburgh and Sharon. The product is unwashed and the output averages about 100 tons per day.

The composition of the sand is shown below:

Silica, SiO_2	95.99%
Alumina, Al_2O_3	1.97%
Ferric oxide	.35%
Calcium oxide, CaO	.09%
Magnesium oxide, MgO	.00%
Titanium oxide, TiO_2	.27%
Loss on ignition	.62%

Microscopic examination of this sand showed the following minerals which are named in the order of their abundance:

1. Quartz.
2. Limonite.
3. Kaolinite.
4. Tourmaline.
5. Feldspar.
6. Zircon.
7. Apatite.
8. Rutile.

Kaolinite is thought to be the cementing material.

Portage Silica Company. This company operates the largest plant in Ohio, located on the Erie Railroad in the extreme eastern part of Portage County, about midway between Garrettsville and Phalanx.

The company owns about 1,100 acres of land, approximately one-half of which is reported to be underlaid with Sharon

conglomerate. The quarry is about 1½ miles north of the mill and has a face three-fourths of a mile long, with a maximum height of 60 feet. The rock is a mass of loosely cemented quartz pebbles, the largest measuring about two inches in diameter. The color of the rock face is buff, except near the base, where it is gray.

The rock is crushed, screened and washed and in the process between 2 and 3 per cent of the material is reported to be lost. Steel molding sand is the principal product. Only one grade is made and that must pass through an eight-mesh screen. The market for this material includes Ohio, West Virginia, Pennsylvania, New York, Michigan, and Indiana.

Other products of this plant are core sand, sand blast sand, filter sand and gravel, roofing gravel, traction sand and gravel for highway construction. Sand blast sand is shipped to New England, Alabama, Iowa and intermediate states. Filter sand and gravel have even a wider market. Sand blast sand is dried by artificial heat, re-screened and divided into five grades. About 200,000 tons of material are shipped per year during normal times.

Three samples of sand gave the following results:

	Steel molding sand, washed.	Fine-grained blast sand, washed.	Coarse-grained blast sand, washed.
Silica, SiO_2	98.14	98.46	98.04
Alumina, Al_2O_3	.16	.17	.24
Ferric oxide	.35	.23	.28
Calcium oxide, CaO	.38	.17	.21
Magnesium oxide, MgO	.05	.00	.01
Titanium oxide, TiO_2	.08	.03	.03
Loss on ignition	.31	.28	.30

A microscopical examination of steel molding sand from this plant showed the following minerals, named in order of their abundance:

1. Quartz.
2. Zircon.
3. Kaolinite.
4. Limonite.
5. Muscovite.
6. Tourmaline.
7. Microcline.
8. Monazite.
9. Hematite.
10. Chlorite.
11. Apatite.

Geauga Silica Sand Company. This plant is located at Geauga Lake, on the Erie Railroad, in the northwest corner of Portage County. A ledge of coarse Sharon sandstone 40 feet thick is worked and the superintendent of the plant claims that 45 feet of good stone lies below the base of the present quarry. The face of the quarry has a buff color, due to the oxidation of the iron content. No pebbles were seen, but they were reported to be present in places.

The rock is broken in a gyratory crusher and then reduced to sand in a disintegrator. It is neither screened nor washed and only one grade is marketed. This is for steel molding and the market extends from Cleveland to Pittsburgh. About two cars of sand are produced per day during summer and one-half as much during winter. It is proposed, however, to discontinue crushing the rock hereafter during winter and to supply the trade during that season from the stock pile. The plant was opened in 1911 or 1912.

Bedford Silica Products Co. This plant is situated in the northeast quarter of Northfield Township, Summit County, where the company owns 20 acres and is now working a ledge 33 feet thick. It is about one mile east of the Pennsylvania Railroad with which it has switch connection. The Sharon conglomerate is covered with about 4 feet of mantle rock which is removed by a wheel scraper drawn by a tractor. The rock has the usual buff color, but in places has small black spots, probably due to iron. Pebbles occur near the base of the quarry and the largest measure about 1½ inches in diameter. A gasoline well-drilling outfit prepared the rock for shooting.

The rock is loaded on cars by a steam shovel, drawn to the mill by horse power and elevated by cable. It is broken in a gyratory crusher, screened and the coarse material passed through a disintegrator. The sand is not washed. The product finds a market for steel castings and the coarse material for furnace bottoms. Northeast Ohio and adjacent parts of West Virginia and Pennsylvania provide a market. The company also makes a specialty of sand for plaster, which finds a ready sale at Cleveland. For this purpose a drying plant is now being constructed.

About 20 men are employed when the plant is operating to capacity and the output is from 175 to 200 tons of sand per day. Work continues throughout the year, except in the

coldest weather. This quarry is reported to have been opened about 30 years ago and to have supplied much heavy stone for a breakwater at Cleveland. The sand plant was erected in 1909 and has been in possession of its present owners for approximately 10 years.

Following are two analyses of the sand, the first from a bin sample and the second from chips from the lower part of the quarry:

	Sand from bin.	Chips from lower part of the quarry.
Silica, SiO_2	98.00	98.29
Alumina, Al_2O_3	.36	.69
Ferric oxide	.53	.18
Calcium oxide, CaO	.01	.00
Magnesium oxide, MgO	.08	.00
Titanium oxide, TiO_2	.00	.04
Loss on ignition	.34	.28

Microscopic examination of the first sample showed the following minerals, named in order of their abundance:

1. Quartz.
2. Limonite.
3. Kaolinite.
4. Feldspar.
5. Muscovite.
6. Zircon.
7. Sericite.
8. Apatite.
9. Titanite.

Summit Silica Company. This is located just south of Barberton, Summit County. A ledge of Sharon conglomerate, 45 feet high, is the basis of the industry. In places the pebbles make up the mass of the rock, while elsewhere they may be restricted to the upper part and in other places to the lower part of the quarry. Most of the pebbles are less than one inch in diameter, but one measuring 3 inches was found. Practically all colors occur, but light shades prevail. Large cracks filled with clay were observed and some of these extended to the base of the quarry. Moreover, chunks of clay were noted in places in the rock.

After blasting, the rock is loaded on cars with a steam shovel and hauled to the mill with mules, where it is reduced to sand by a gyratory crusher, disintegrator, and rolls. The material is then washed and that for sand blasting passed through a cylinder drier, after which it is screened. The coarse material from the screens is put through the rolls, after

which it is re-screened. The sand is used for steel castings, blasting sand, glass making, and for concrete. The pebbles are the source of sand for blasting, while the sand proper yields molding and glass sands. Three grades of molding sand are made and five grades of blasting sand. The market extends from Pittsburgh to Chicago and Milwaukee.

A sample of unwashed and unscreened sand from this plant had the following composition:

Silica, SiO_2	97.41
Alumina, Al_2O_3	.58
Ferric oxide	.34
Calcium oxide, CaO	.11
Magnesium oxide, MgO	.00
Titanium oxide, TiO_2	.09
Sodium oxide, Na_2O	.04
Potassium oxide, K_2O	.08
Loss on ignition	.44

Microscopical examination showed the following minerals present. These are named in order of their abundance:

1. Quartz.
2. Magnetite.
3. Zircon.
4. Kaolinite.
5. Feldspar.
6. Muscovite.
7. Apatite.

Franklin Industrial Company. This plant is located on the Pennsylvania Railroad about one mile west of Warwick, Wayne County. A ledge of 50 feet of Sharon conglomerate is the basis of the industry. The rock is reduced in a jaw crusher and then passed through three sets of rolls, after which it is screened. Part of the material is put through a rotary drier. The product is used for steel castings, furnace bottoms, and by traction lines. The output is about 100 tons per day and the plant operates throughout the year.

A sample of unwashed and undried sand from this plant gave the following analysis:

Silica, SiO_2	97.47%
Alumina, Al_2O_3	.72
Ferric oxide	.38
Calcium oxide, CaO	.00
Magnesium oxide, MgO	.06
Titanium oxide, TiO_2	.09
Loss on ignition	.60

Microscopical examination showed the following minerals, which are listed in order of their abundance:

1. Quartz.
2. Tourmaline.
3. Zircon.
4. Limonite.
5. Kaolinite.
6. Microcline.
7. Sericite.
8. Hematite.
9. Rutile.
10. Zenotime.

Oliver Silica Sand Company. This plant is located about one-fourth of a mile east of that of the Franklin Industrial Company. About 40 feet of the Sharon is worked. The rock is treated in much the same manner as in that of the adjacent plant and the product, of course, is similar. Its principal use is for steel castings, furnace bottoms and cores.

Chalfants Plant of the Central Silica Company. This plant is located between Chalfants and Glenford, on the Baltimore and Ohio Railroad, in the northern part of Perry County. The rock is the Sharon and it there shows more variation than was found in the quarries of northeast Ohio. The old quarry just south of the mill has been abandoned, except for the ganister, which ranges from 18 inches to 12 feet in thickness and which lies at the top of the Sharon. The ganister is finer grained than the rock below, is well cemented and has a color which ranges from light gray to brown.

The new quarry which is now the source of rock, except for ganister, is situated nearly a half mile south of the mill. A maximum of perhaps 35 feet of rock, exclusive of 4 to 6 feet of stripping, is worked. The rock is coarse-grained and in places pebbly, but these lie in pockets rather than in beds. At present the stripping is run through the mill, but the company is now removing this waste by a drag line system. The rock is loaded on cars with a steam shovel and transported to the mill by a dinky engine.

The rock is broken in an oscillating crusher and is carried by gravity to a dry pan which is operated wet. This reduces the rock to sand, which is transported by gravity to a 6-mesh rotary screen. Any coarse material which cannot pass through the screen is carried back to the dry pan. From the screen the sand runs into a sluice box and is pumped from there to the washer. Here the coarse sand settles to the bottom and is removed, while the find sand passes over the top with water into a settling tank, where the sand collects on the bottom and the clay is carried with water over the top and flows into the creek. This sand is used for steel molding purposes.

The coarse sand (6-mesh) referred to in the last paragraph is conveyed by gravity to a pile outside of the mill and in that form is used for furnace bottoms and in brick making. Much of the greater part of this pile, however, is transported by a drag to an elevator, which lifts it to the top of the drier, through

which the sand falls, a distance of about 35 feet. From the drier the sand is conveyed by an elevator to a screen, where it is separated into three sizes. The finest passes through a 20 mesh, the medium through a 16 mesh, while the coarsest passes from the end of the screen.

The 20 mesh, or finest sand, is raised by an elevator to a bin above the tube mill into which it runs. This mill measures 20 by 5 feet and has a "silica" lining. It is filled half full with flint pebbles and rotated. The sand remains in this mill about 45 minutes and is from 140 to 200 mesh fineness when it emerges, the difference being dependent on quanity of sand in the mill. The main use of this material, known as Silica Wash, is for painting molds for steel castings; minor uses are for soap, paint, and in rubber works. The market for this product at present extends from Ohio to California.

The medium sand (16 mesh) is used in glass making and on tracks to prevent slipping. The market for this is restricted to Ohio. The coarsest material, or that which does not pass through the screen, is used as steel blast sand.

The sand which collects in the settling tank is used for steel moldings. The ganister is reduced in the dry pan without water and is shipped in that condition.

The plant reduces about 175 tons of rock per day, except in very cold weather, and the product is about as follows:

Silica Wash	15 tons.
Glass sand	80 "
Steel blasting	5 "
Steel molding	2½ "
Furnace bottoms	47 "
Waste	25 "

When the stripping is removed in the quarry the quantity of waste will be very greatly reduced.

Four samples of sand from this plant were analyzed and the results follow:

	Blast sand from pebble, washed.	Ganister sand, unwashed.	Steel molding sand, washed.	Glass sand, washed.
Silica, SiO_2	97.99	98.61	95.66	99.43
Alumina, Al_2O_3	1.08	.39	1.84	.18
Ferric oxide	.22	.20	.19	.13
Calcium oxide, CaO	.00	.00	.00	.00
Magnesium oxide, MgO	.07	.06	.16	.05
Titanium oxide, TiO_2	.08	.20	.22	.04
Loss on ignition	.53	.27	.87	.22

Microscopic examination of the steel molding sand showed the following minerals which are listed in order of their abundance:

1. Quartz.
2. Kaolinite.
3. Zircon.
4. Limonite.
5. Hematite.
6. Tourmaline.
7. Magnetite.
8. Titanite.
9. Muscovite.
10. Feldspar.
11. Sericite.
12. Apatite.

Examination of three additional varieties of sand from this plant disclosed quite a variation in the relative abundance of the minerals, though of course quartz in all was by far the most plentiful.

Jackson Sand Mining Company. This, the southernmost steel molding sand plant in Ohio, is located on the Cincinnati, Hamilton & Dayton Ry., 2 miles north of Coalton, Jackson County. The rock is the Sharon, but it is a sandstone, rather than a conglomerate. The sandstone measures about 70 feet in thickness and forms two benches, separated by a thin layer of clay. The lower bench is the coarser grained.

The rock is reduced by a hammer pulverizer and is screened but not washed. Two grades of sand are marketed, the white and the light yellow. The product is used as molding sand for steel and iron castings, furnace bottoms and brick kiln sand. This plant has been in continuous operation for about 25 years.

Two samples of sand and one sample of uncrushed rock were analyzed with the following results:

	Sand from top ledge.	Sand from bottom ledge.	Uncrushed rock.
Silica, SiO_2	96.79	98.50	96.19
Alumina, Al_2O_3	2.00	.70	2.22
Ferric oxide	.20	.22	.20
Calcium oxide, CaO	00	.10	.00
Magnesium oxide, MgO	.08	.00	.03
Titanium oxide, TiO_2	.17	.10	.18
Loss on ignition	.55	.35	.65

A sample of uncrushed rock was examined microscopically and the following minerals identified. They are listed in order of their abundance.

1. Quartz.
2. Zircon.
3. Muscovite.
4. Kaolin.
5. Microcline.
6. Limonite.
7. Hematite.
8. Rutile.
9. Xenotime.

THE MASSILLON SANDSTONE.

As the section of the Pottsville formation given on a preceding page shows, the Massillon sandstone is divided into two parts by the Quakertown or No. 2 coal. At Massillon, the type locality, the Upper Massillon sandstone, 60 feet thick, is well shown in the Everhard quarry on the west bank of the Tuscarawas River, while at Pauls, about 4 miles farther up stream, the Lower Massillon sandstone was formerly quarried.

The following section in the Everhard quarry shows very well the rock succession:

	Ft.	In.
Upper Massillon—Stripping, rejected	12	0
Sandstone, much broken, uneven bedded, coarse-grained, not as good as sandstone below with which it is mixed in proportion of 1 to 2	25	0
Clay shale, rejected	10	0
Sandstone, massive, used for silica sand	35	0
Shale, part siliceous	33	0
Anthony coal, bony	0	2
Sciotoville clay, siliceous, light-colored	8	6
Shale, dark-colored	3	0

In Holmes County, southwest of Massillon, the two sandstones are well developed. The lower division is represented partly by shales, but the upper division appears to consist more largely of sandstone.[1] The rock is well developed in Muskingum County where in places it is slightly conglomeratic.[2] Along the western border of the Hocking Valley coal field, Orton reports both members of the Massillon sandstone present, the upper in places very pure and from 10 to 20 feet thick, while the lower is "often heavy."[3] In Scioto County in the extreme southern part of Ohio, thick sandstones on the horizon of the Massillon are shown in numerous sections.[4]

From what has just been said, it appears that the Massillon sandstone extends across the State much as does the Sharon conglomerate, though the latter by reason of its texture is much the more conspicuous.

The Massillon sandstone is used in a large way at Massillon for steel molding sand and several other purposes. It was formerly quarried for building stone and many structures of it may be seen in Massillon and near-by cities.

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[1] A. A. Wright, Geol. Survey of Ohio, Vol. 5, p. 818.
[2] W. Stout, Geol. Survey of Ohio, Bull. 21, p. 60.
[3] Edward Orton, Geol. Survey of Ohio, Vol. 5, p. 991.
[4] W. Stout, Geol. Survey of Ohio, Bull. 20.

The Everhard Company. In the Everhard quarry, which was opened in 1884, a maximum of 60 feet of sandstone is quarried. The rock is broken by two jaw crushers and is further reduced in rolls. It is then passed through a rotary drier and finally over screens. The coarse material caught by the screens is returned to the finishing rolls and is again screened. During the milling, dust is withdrawn by high speed fans and the product marketed. The capacity of the plant is about 200 tons per day.

The products are steel molding sand, furnace sand, core sand, and formerly glass sand. The molding sand is passed through a 5 mesh screen, while the furnace sand is passed through a 2 mesh. The molding sand is well adapted for large steel castings and has a market at Pittsburgh, Cleveland, and Cincinnati, as well as at intermediate places. Massillon is the chief market for core sand. In recent years but little sand has been marketed for glass making and the rock must be carefully sorted for this purpose.

Four samples from this plant were analyzed and the results follow:

	Furnace bottom sand.	Core sand.	Dust from mill.	Selected chips from quarry face.
Silica, SiO_2	96.29	95.75	84.02	96.51
Alumina, Al_2O_3	1.63	1.60	8.78	1.90
Ferric oxide	.33	.81	2.09	.58
Calcium oxide, CaO	.03	.00	.03	.07
Magnesium oxide, MgO	.00	.02	.02	.01
Titanium oxide, TiO_2	.20	.15	.72	.12
Sodium oxide, Na_2O	....	.12	....	....
Potassium oxide, K_2O	....	.26	....	....
Loss on ignition	.43	.68	2.65	.56

Carefully selected chips from the quarry face, when examined with a microscope, showed the following minerals present. They are named in order of their abundance.

1. Quartz.
2. Limonite.
3. Kaolinite.
4. Feldspars.
5. Muscovite.
6. Hematite.
7. Sericite.
8. Zircon.
9. Magnetite.

Newman Silica Sand Company. This plant is located on the Baltimore and Ohio and Pennsylvania railroads, about one-half mile above Pauls, Stark County. The rock is broken in a jaw crusher and then passed through two sets of rolls, after which it is washed and some of it screened. It is then ready for shipment. The sand is used for steel molding and furnace bottoms. It was formerly used in glass manufacture. The capacity of the plant is about 100 tons per day.

A ledge of 30 feet of sandstone is worked, above which is 4 to 6 feet of stripping. The sandstone is coarse, has a buff color and parts are impregnated with iron. A dark shale lies below the sandstone and still lower the Massillon or No. 1 coal is reported. The rock is loaded by hand and hauled to the mill by gravity.

For many years the Lower Massillon sandstone was worked at Pauls for foundry facings, furnace bottoms, and to a small extent for glass, but the plant was destroyed by fire a few years ago and it has not been rebuilt.

THE DUNDEE SANDSTONE.

The Dundee sandstone lies near the middle of the Pottsville formation. It cannot be said to be steady or persistent, however, for its place is frequently occupied by shales, but it is well developed locally and in a few places is of value.

The one locality where the Dundee sandstone is worked in the large way is the valley of Sugar Creek in the northwest corner of Tuscarawas County. The stream has there cut a deep trench in the sandstone and has thus made it readily available.

The plant at Barrs Mills, operated by the Massillon Sand Stone Company, is the best equipped and the largest producer in the valley. The sandstone worked averages about 50 feet in thickness and has a maximum of about 67 feet. Most of the rock has a buff color, but the lower part is in places light gray. It is coarse grained, but without pebbles.

The rock is transported to the mill by horse power and elevated by cable. It is broken in a gyratory crusher and reduced to sand in a disintegrator. Most of the sand is dried and screened, the coarser material then passing through a set of rolls and being re-screened. Dust is blown from the sand

while it is in the drier and is used for small steel cores, glazing tile, and plaster. The product of this plant is used principally for steel castings and furnace bottoms. Minor uses are on traction lines, in brick making, and to a smaller extent in the manufacture of glass. Pittsburgh is the principal market.

The plant produces 200 tons of sand per day on the average. It is said to have been in operation about 30 years as a sand plant and prior to that time the quarry was worked for dimension stone.

The composition of the sand from this and adjacent plants in Sugar Creek Valley is shown by the following analyses:

	Massillon Sand & Stone Co. Unwashed, Barrs Mills	National Malleable Castings Co. Unwashed, Dundee	Beach City Silica Sand Co. Unwashed.
Silica, SiO_2	98.28	96.63	97.76
Alumina, Al_2O_3	.32	2.00	.69
Ferric oxide	.24	.42	.34
Calcium oxide, CaO	.00	.00	.00
Magnesium oxide, MgO	.13	.04	.11
Titanium oxide, TiO_2	.07	.20	.05
Loss on ignition	.32	.60	.40

Microscopical examination of a run-of-quarry sample of sand from the plant of the Massillon Stone Company at Barrs Mills showed the presence of the following minerals which are listed in order of their abundance:

1. Quartz.
2. Microcline.
3. Feldspars.
4. Limonite.
5. Kaolinite.
6. Tourmaline.
7. Chlorite.
8. Zircon.
9. Titanite.
10. Serpentine.

Dundee, which is situated about 3 miles north of Barrs Mills, has long been an important sand producer. Here are located the plant of the National Malleable Castings Company and that of the American Sand Company. Both work the Dundee sandstone, the rock being broken in gyratory crushers and then passed through rolls and over screens. Steel castings and furnace bottoms are the principal uses of the product.

The plant of the Beach City Silica Sand Co., which is located about midway between Dundee and Beach City, was opened in 1910. A ledge of about 50 feet of the Dundee sandstone is quarried and the rock hauled to the mill by gravity. The rock is broken in a jaw crusher and then run through three sets of rolls, after which it is screened, and where desired, washed and dried. Very fine sand is produced by grinding the material in a rotating steel cylinder which contains rounded flint pebbles. The market is chiefly for steel castings, furnace bottoms, cores, potteries, brick yards, and for glass making. From 4 to 5 cars a day are shipped on the average.

THE ALLEGHENY FORMATION.

The Allegheny formation contains extremely valuable beds of coal and clay and less valuable deposits of limestone, iron ore, and sandstone.

Only one sandstone of this formation is now quarried for steel molding sand and that at a single locality—Strasburg, Tuscarawas County. The territory is notable for its resources, as it contains a good bed of the Lower Kittanning or No. 5 coal and below it the most refractory clay of Ohio. Following is a composite section:

	Ft.	In.
Lower Kittanning, No. 5 coal	3	3
Plastic fire clay	3	6
Flint fire clay	3	0
Plastic fire clay	4	6
Sandstone, measured	58	0

The White Rock Silica Sand Co. This is the one plant which produces steel molding sand from the Allegheny formation. The sandstone which is shown in the above section measures, where quarried, 58 feet, but the top 8 feet are shaly. The rock is coarse grained, massive, gray to buff in color, and carries in places black coaly material, which is sorted out by the workmen.

A gasoline engine hauls the rock to the mill, where it is broken in a jaw crusher and then reduced to sand by two sets of rolls. The sand is screened for steel castings, cores, and brick yards. Furnace sand is not screened. The plant does not have a washer. A great quantity of raw material is available.

The following analyses show the composition of the sand:

	Furnace bottom sand. Unwashed.	Steel molding sand. Unwashed.
Silica, SiO_2	96.87	96.52
Alumina, Al_2O_3	1.20	1.83
Ferric oxide	.45	.31
Calcium oxide, CaO	00	.00
Magnesium oxide, MgO	.06	.03
Titanium oxide, TiO_2	.11	.17
Loss on ignition	.43	.39

Microscopical examination of the steel molding sand showed the following minerals which are named in the order of their abundance:

1. Quartz.
2. Kaolinite.
3. Limonite.
4. Tourmaline.
5. Microcline.
6. Muscovite.
7. Zircon.
8. Magnetite.
9. Hematite.
10. Epidote.
11. Xenotime.
12. Rutile.

THE COMPARATIVE RESISTANCE OF DIFFERENT SPECIES OF EUGLENIDAE TO CITRIC ACID.*

W. J. Kostir,
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In the course of his experiments on the nutrition of *Euglena gracilis*, Zumstein (1900) discovered that this species is able to tolerate surprisingly high concentrations of certain organic acids. He made use of this fact to obtain cultures free, or nearly free, from bacteria. Adding various proportions of the acid to the culture medium employed, he found that while the multiplication of bacteria was effectively inhibited, rich cultures of apparently normal Euglenæ could be obtained. Ternetz (1912) working with the same species, also made use of this method.

Of several organic acids experimented with, Zumstein found citric acid to be the least harmful to this organism. He reports that solutions of 0.5 to 2% are "not injurious," and that cultures to which these percentages of the acid had been added were quite successful. Whether all the individuals used in inoculating these cultures survived the transfer to the acid medium is unfortunately not clear from Zumstein's account. In the case of "3 and 4%," he states that many individuals remained living even after 88 hours. In "4 and 5%" many were actively moving after five days. In "5 and 6%" a few remained alive even after 17 days. Higher concentrations were apparently found to be uniformly fatal, though Zumstein makes no definite statement as to the lowest percentage sufficient to kill all the individuals exposed to it.

Unfortunately, the results of these experiments have been interpreted by the writers of certain text-books and manuals in a way not at all justified by the facts. Results obtained on a single species have been made the basis for generalizations concerning the whole genus Euglena, and even the family Euglenidæ. Prowazek, in his "Einfuehrung in die Physiologie der Einzelligen" (1910), Lemmermann, in the section on the Euglenidæ in "Die Suesswasserflora Deutschlands, Oesterreichs, und der Schweiz" (1913), and Doflein, in the fourth

* Contribution No. 66 from the Department of Zoology and Entomology, Ohio State University.

edition of his text-book (1916) all either definitely state or imply that a high degree of resistance to organic acids is characteristic of Euglenæ (or even of Euglenidæ) in general.

The present writer became interested in this matter when, having successfully cultivated *Euglena gracilis* in strongly acid media, he attempted to use similar methods with *Euglena deses*. These attempts met with failure in every case, and even relatively weak solutions of citric acid proved fatal to this species.

How was this to be interpreted? Is the case of *Euglena deses* merely a striking exception to the general rule for the group? Or is *Euglena gracilis* the exceptional form? Or, lastly, may it be that no general rule for the group is justified?

Good cultures of several species of Euglena and of one species of the closely related genus Phacus were at hand at the time, and it occurred to the writer that a comparatively simple series of experiments with them might throw light on these questions. Such a series of experiments was actually planned and carried out, as described in the following paragraphs.

A quantity of clear surface water was procured from a near-by pond (known to be a habitat of several species of Euglena), and filtered. Tests showed it to be decidedly alkaline in reaction. By careful titration, using neutral red as an indicator, it was found that 1 c. c. of 1% HCl (chemically pure) was needed to bring 190 c. c. of this water to the point of neutrality corresponding to that of distilled water. Accordingly, the original quantity of filtered water was now divided into two parts, one of which was left unchanged, while the other was made neutral by the addition of the appropriate quantity of 1% HCl. With this neutralized pond water the following solutions of citric acid were then made up (chemically pure citric acid being employed): .025%, .05%, .1%, .25%, .5%, 1%, 2%, 3%, 4%, 5%.*

As seven different species were available for the experiment, seven series of these solutions were now put into Syracuse watch

*It may be noted that the hydrogen ion concentration of these solutions is by no means proportional to the concentration of the acid, since the degree of ionization decreases as the concentration of the acid becomes greater. But the work of Collett (Jour. Exp. Zool., 1919) and others has shown that other factors besides hydrogen ion concentration are involved in the toxicity of organic acids; hence, for the purposes of these experiments, known concentrations of the acid are preferable to known concentrations of hydrogen ions. Per cent solutions were used rather than molar solutions in order to make the results directly comparable to those of Zumstein.

glasses, 5 c. c. of liquid in each watch glass. To each series were added, in similar glasses, both neutralized and unneutralized pond water without citric acid, these to serve as controls; and each series was then inoculated with a different species, about five or six individuals being introduced into each watch glass. The quantity of culture medium introduced with these was so slight as to be negligible. As the watch glasses were kept stacked (close to a north window and away from the direct rays of the sun) except when actually being handled, it is evident that evaporation was also a negligible factor.

Since the object was purely to get a measure of the *comparative* resistance to the acid, no attempt was made to determine the length of time that the organisms could live in a given concentration of the acid. Instead, all the watch glass cultures were very carefully examined just 24 hours after inoculation, and the condition of every individual was noted. In every case all the organisms in the controls (both neutralized and unneutralized pond water) were found to be alive and normal in every way, showing that the results observed in the other solutions were actually due to the addition of the citric acid, and not to anything in the original pond water, nor to the HCl introduced in neutralizing it.

The results from the citric acid solutions are concisely expressed in the accompanying table. In each case where all the individuals in the watch glass were still alive after 24 hours, the proper space has been left blank. Where part of the individuals were dead, an asterisk (*) is used; and where all were found dead, a large ×. In the case of each species, therefore, the column with the last blank space (counting from left to right) indicates the highest percentage of the acid successfully withstood by one hundred per cent of the individuals tested; while the column with the first × indicates the lowest percentage causing the death of one hundred per cent.

The criterion used in determining whether an individual was dead or alive was the unmistakable change in color and appearance which ensues shortly after death has occurred. Movement can not be used as a criterion in this group, since individuals may temporarily remain perfectly motionless for a considerable length of time.

It will readily be seen from the table that the tolerance of different individuals of the same species is not necessarily the same. Some of the *Euglena deses*, for example, succumbed to the .05%, while the rest were killed by the .1%. In *Euglena gracilis* the variability in this regard is very great, a fact shown by Zumstein's results also. Similar physiological variability among the individuals of a species and even in the same culture is a phenomenon which the writer has repeatedly observed in connection with factors other than acidity. Its significance remains to be shown.

TABLE I.

PERCENTAGES OF CITRIC ACID CAUSING DEATH WITHIN 24 HOURS.

*—Some, but not all, dead.
×—All dead.

	.025%	.05%	.1%	.25%	.5%	1%	2%	3%	4%	5%
E. deses Ehrenb.		*	×	×	×	×	×	×	×	×
E. acus Ehrenb.			×	×	×	×	×	×	×	×
E. geniculata Duj. (?)			×	×	×	×	×	×	×	×
E. ehrenbergii Klebs			*	×	×	×	×	×	×	×
E. oxyuris Schmarda				×	×	×	×	×	×	×
Ph. anacoelus Stokes				×	×	×	×	×	×	×
E. gracilis Klebs							*	*	*	×

The most striking fact brought out by a perusal of the table is the remarkable difference between *Euglena gracilis* and all the other species. Thus the species first studied in this connection, and assumed by various writers to be typical of the other species of its group, is seen to be decidedly exceptional when compared with the six other forms that have been tested.

One discrepancy between these results and those of Zumstein may be noted. All the individuals of *Euglena gracilis* in the 5% solution were found dead; while Zumstein states that a few remained alive in 5 and 6%. In view of the great variability which we have noted in this species, and the relatively small

numbers of individuals tested, this difference is undoubtedly without significance.

Further study on the physiology of these interesting organisms, to include, it is hoped, a more detailed investigation of their behavior toward acids, is in progress.

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NEW FORMS OF OEDOGONIUM*

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Some algal collections made from lakes in the vicinity of Akron, Ohio, in the summer of 1920 contained a species and a variety of *Oedogonium* apparently undescribed. In accordance with the rules of the Vienna Congress a Latin and an English diagnosis of each is given.

Oedogonium exocostatum nov. sp.

Oedogonium dioicum; macrandrium; oogoniis singulis vel binis, ellipsoideis vel globoso-ellipsoideis, rarius terminalis; poro superiore apertis; oosporis eadem forma ac oogoniis, hæc plane complentibus, membrana duplici; episporio longitudinaliter costato (in sectione optica transversali undulato), costis integris, raro anastomosantibus, in medio oosporae circa 13–15, endosporio lævi; cellulis suffultoriis tumidis; plantis masculis paululo gracilioribus quam femineis; antheridiis 3–7 cellularibus; spermatozoidis binis, divisione horizontalis; cellula fili basali forma, ut vulgo elongata;

Crassit. cell. veg. plant. fem. (13–)	18–25 μ	altit. 72–140 μ
Crassit. cell. veg. plant. masc. (13–)	16–20 μ	altit. 48–100 μ
Crassit. cell. suff.	22–30 μ	altit. 60–90 μ
Crassit. oog.	40–52 μ	altit. 68–96 μ
Crassit. oos.	38–41 μ	altit. 60–68 μ
Crassit cell. antherid.	12–16 μ	altit. 7–12 μ

Diœcious, macrandrous, oogonia single or often two, ellipsoid to ellipsoid-globose, occasionally terminal, pore superior; oospores of the same form as the oogonia which they very nearly completely fill, membrane double; the outer spore wall marked by 13–15 longitudinal ribs, inner wall smooth; suffultory cells swollen; male filaments a little more slender than the female, antheridia 3–7 celled, sperms two, division horizontal; basal cells elongate.

Diam. veg. cells, female plant (13–)	18–25 μ	length 72–140 μ
Diam. veg. cells, male plant (13–)	16–20 μ	length 48–100 μ
Diam. suffultory cells	22–30 μ	length 60–90 μ
Diam. oogonia	40–52 μ	length 68–96 μ
Diam. oospores	38–41 μ	length 60–68 μ
Diam. antheridial cells	12–16 μ	length 7–12 μ

* Papers from the Department of Botany, Ohio State University, No. 128.

In appearance this species is near *Oedogonium cyathigerum* Wittr. It differs, however, in being macrandrous, in having a smaller number of ribs, and in having the ribs on the outer wall instead of the inner wall of the oospore. It is easily distinguished from *Oedogonium crenulato-costatum* Wittr. by its swollen suffultory cells, its spore markings, and its larger dimensions throughout. Among the operculate species it bears some resemblance to *Oedogonium pauco-costatum* Transeau.

Found rather abundant in Dollar Lake and Summit Lake, near Akron, Ohio, August, 1920. Type in L. H. T. collections, Nos. 196, 198. Plate I, Fig. A-F.

Oedogonium pauco-costatum Transeau var. **gracilis** nov. var.

Var. omnibus partibus gracilior; oosporis ellipsoideis vel globoso-ellipsoideis, oogonia fere complentibus vel non complentibus; ceterum ut in typo;

Crassit. cell. veg.	15–20 μ altit. 66–120 μ
Crassit. oog.	48–52 μ altit. 70–88 μ
Crassit. oos.	44–48 μ altit. 60–70 μ
Crassit. cell. antherid.	17–20 μ altit. 8–12 μ

Somewhat smaller than the species; the oospore is ellipsoid or occasionally globose-ellipsoid, completely filling the oogonia or not filling the oogonia; otherwise similar to the type;

Diam. veg. cells	15–20 μ length 66–120 μ
Diam. oogonia	48–52 μ length 70–88 μ
Diam. oospore	44–48 μ length 60–70 μ
Diam. antheridial cells	17–20 μ length 8–12 μ

This variety bears some resemblance to *Oedogonium Australianum* Hirn. It differs, however, in having largely elliptical oospores, in the similarity of the vegetative cells of the male and female filaments, and in the smaller number of ribs on the median spore walls. It seems most closely related to *Oedogonium pauco-costatum* Transeau in its general habit of growth. It was found associated with *Oedogonium taphrosporum* Nordst. and Hirn.

Collected at Turkeyfoot Lake near Akron, Ohio, August, 1920. Type in L. H. T. collections Nos. 177, 182.

EXPLANATION OF PLATE.

Figures A–F **Oedogonium exocostatum** nov. sp.

A—Female filament with two oogonia and two oospores, one of the latter immature.

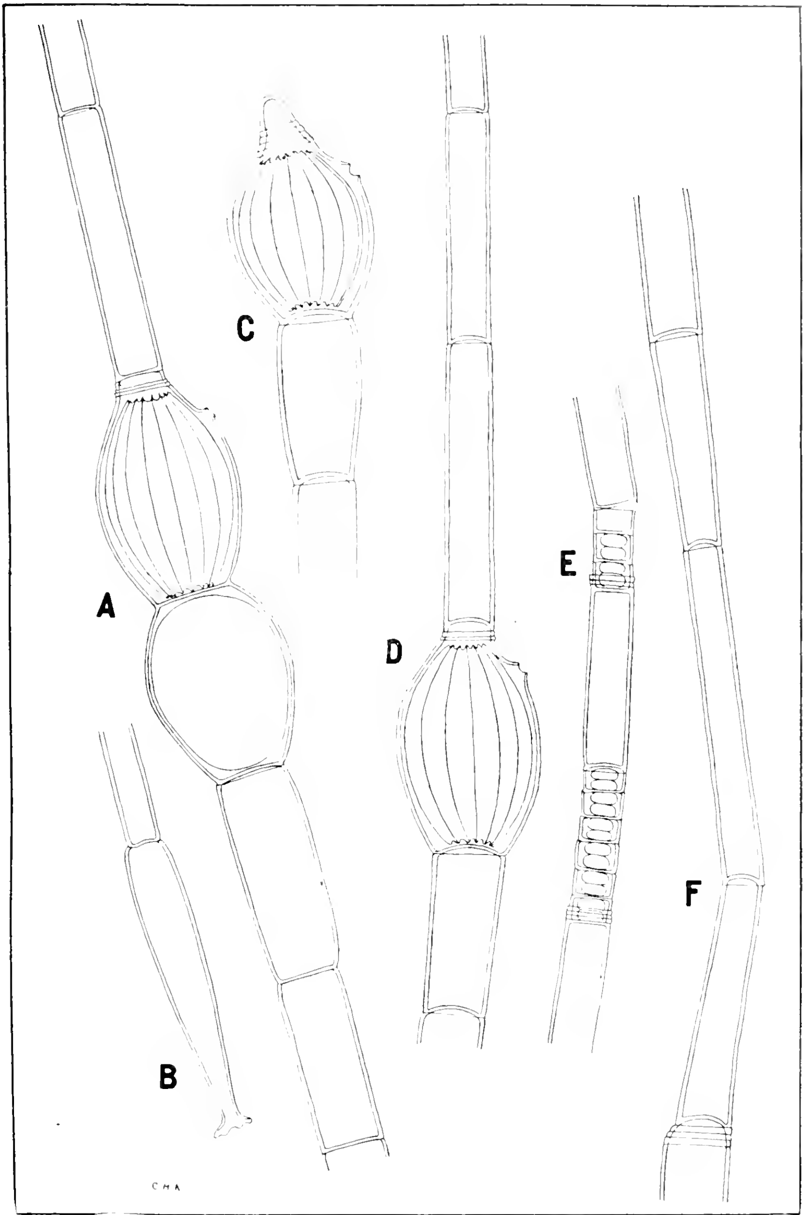
B—Elongated basal cell, showing habit of attachment.

C—Female filament, showing terminal oogonium with mature oospore.

D—Female filament with oogonium, oospore mature.

E—Male filament with antheridia containing sperms.

F—Portion of vegetative filament showing variability in cell diameter and elongation. Camera lucida drawings.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FUNDS FOR SCIENTIFIC RESEARCH.

The Research Information Service of the National Research Council has recently compiled information about funds for scientific research. From this compilation it appears that there are hundreds of special funds, trusts, or foundations for the encouragement or support of research, in the mathematical, physical and biological sciences, and their applications in engineering, medicine, agriculture and other useful arts. The income from these funds, which amounts annually to at least fifty million dollars, is used principally for prizes, medals, research scholarships and fellowships, grants and sustaining appropriations or endowments.

So numerous have been the requests to the Research Council for information about sources of research funds, availability of support for specific projects and mode of administration of particular trusts or foundations, that the Research Information Service has created a special file which it is proposed to keep up to date in order to answer the questions of those interested in such funds. Furthermore, in order to give wider publicity to the immediately available information about research funds, the Council has issued a bulletin under the title "*Funds available in 1920 in the United States of America for the encouragement of scientific research.*"

Inquiries concerning the bulletin or for information about research funds should be addressed, National Research Council, Information Service, 1701 Massachusetts Avenue, Washington, D. C.

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